

ECONOMIC AND SOCIAL IMPACTS OF TRIUMF

Prepared for:

TRIUMF

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1. Executive Summary

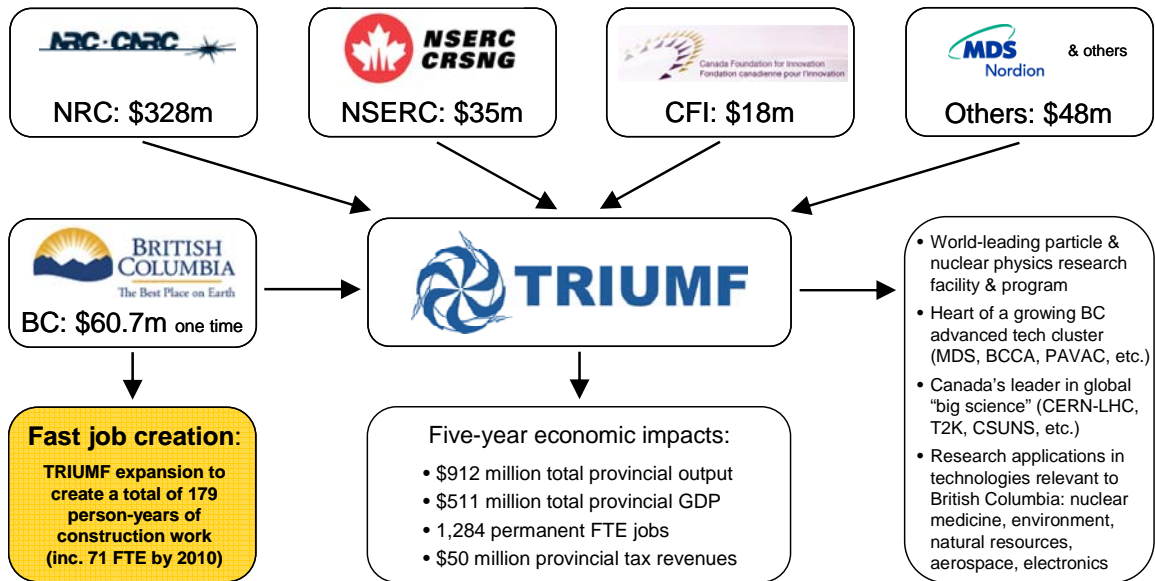
TRIUMF is seeking \$60.7 million in Provincial government funding to support three proposed facility expansions. These facility expansions are modest relative to the overall scale of the TRIUMF research facility, but add important new capabilities to keep TRIUMF on the leading edge of global particle and nuclear physics.

This report assesses the expected economic impacts of TRIUMF’s ongoing operations both with and without the proposed facility expansion, to determine the net incremental economic impacts if the proposed facility expansions proceed. This report also examines the broader socio-economic impacts that TRIUMF generates within British Columbia.

The total impacts estimated to be generated by TRIUMF over the next five years are summarized in Exhibit 1.1, assuming that the proposed facility expansion proceeds. Inclusive of direct, indirect and induced impacts, it is estimated that TRIUMF will generate \$912 million in provincial output, \$511 million in provincial GDP, \$50 million in provincial tax revenues, and 1,284 FTE jobs over the coming five years.

These impacts are in addition to construction jobs that will be created by the facility expansion project. It is estimated that 179 person-years of construction employment will be created between 2009 and 2012, with 71 FTEs being created by 2010.

Exhibit 1.1
Summary of impacts of TRIUMF and the proposed facility expansion.
Estimated total economic impacts for 2010 to 2014¹



1. Economic impacts include direct, indirect and induced impacts of TRIUMF operations, but exclude impacts related to the \$60 million cost of construction for the proposed facility expansion.

While Exhibit 1.1 summarizes the total estimated impacts of TRIUMF over the next five years, assuming that the facility expansion proceeds, this report also assesses the impacts of TRIUMF if the facility expansion does not proceed. Comparing these two scenarios, the TRIUMF expansion is forecast to have a strong net positive economic impact on British Columbia – generating increases in economic activity and preventing a decline from TRIUMF’s current levels of economic activity. Over the shorter term, the one-time investment of \$60.7 million is expected to result in:

- A net increase of \$125 million in federal/NRC funding for TRIUMF over the five years from 2010 to 2014, from \$203 to \$328 million.
- A net increase in total provincial GDP \$156.5 million over five years.
- A net increase in total provincial employment of 373 FTE jobs.
- A net increase in Provincial tax revenues of \$15.5 million over five years.

In the longer term, failure to re-invest in TRIUMF’s facilities and infrastructure may lead to the closure of the facility, due to it falling behind the pace of world-leading research. This would result in the loss of more than 1,000 existing jobs in British Columbia and more than \$78 million in existing annual Provincial GDP.

In addition to these pure economic impacts, TRIUMF also generates a range of broader socio-economic impacts that cannot be so readily quantified. In particular:

- TRIUMF represents the heart of a growing advanced technology cluster in British Columbia focussed on nuclear medicine and particle accelerator technology. TRIUMF’s existence directly supports private industry in BC (e.g., MDS Nordion, Advanced Cyclotron Systems, PAVAC Industries, and D-Pace) as well as not-for-profit agencies and organizations (e.g., BC Cancer Agency and Advanced Applied Physics Solutions, Inc.).
- TRIUMF leads Canada’s role in global “big science” collaborations (e.g., CERN Large Hadron Collider, T2K, CSUNS) that are seeking answers to questions of fundamental physics such as the cause of the big bang, the dominance of matter over anti-matter in the universe, and the existence of parallel dimensions of time and space. TRIUMF’s leadership role in these collaborations keeps BC scientists at the forefront of global science, attracts highly qualified personnel to BC to live and work, and provides opportunities for domestic firms to participate in the supply of equipment and apparatus required by these global projects.
- TRIUMF research projects include applied research into technologies that have the potential to be of significant practical benefit to British Columbia, Canada, and Canadian industry. These projects include applications in healthcare (e.g., treatment of diseases including Parkinson’s, diabetes, Alzheimer’s, and various cancers), the environment (e.g., reductions in CO₂ and other pollutants), natural resources (e.g., improved efficiency in papermaking and improved interpretation of geological data), and industry (e.g., aerospace systems and electronics design).

These benefits further accentuate the importance of TRIUMF in maintaining and enhancing the competitiveness of the BC economy in this technology-driven era. Relative to the benefits produced, the investment required to keep TRIUMF on the leading edge of global particle and nuclear physics appears to be modest.

2. Background & Objectives

2.1. Background on TRIUMF

TRIUMF is Canada's national laboratory for particle and nuclear physics, funded primarily by the Government of Canada (via the National Research Council). Physically located at the University of British Columbia, TRIUMF is owned and operated by a consortium of Canadian universities which currently includes seven full member universities and seven associate member universities. This consortium may grow in the future, as a number of universities have applied to join and/or upgrade their memberships.

The core of TRIUMF's research and work is the world's largest cyclotron particle accelerator, as well as smaller cyclotron and linear accelerators. Using these accelerators, TRIUMF's work encompasses both pure and applied research and commercial applications in:

- **Nuclear medicine**, including the production of specialized medical isotopes that complement the output of Canada's world-leading Chalk River nuclear facility in Ontario. TRIUMF-produced isotopes supply the BC Cancer Agency and Pacific Parkinson's Research Centre, among others. The adjacent MDS Nordion facility (which is independently owned, but dependent upon TRIUMF staff and in part upon the main TRIUMF cyclotron) produces commercial volumes of isotopes for medical-imaging scans.

TRIUMF has also been instrumental in the development of small-scale cyclotrons that can be installed by nuclear medicine agencies to produce their own isotopes in-house, avoiding the transportation of such isotopes. TRIUMF is now providing installation and ongoing technical services, as well as isotope backup services, to a variety of nuclear medicine centres across Canada.

- **Nuclear and particle physics**. Through the development of several highly specialized beam lines that can deliver beams of rare particles, TRIUMF has become one of the world's leading centres for the study of nuclear astrophysics and element synthesis in the universe. Through its focus on these programs, TRIUMF has earned an international reputation in accelerator science and technology.

As a result, TRIUMF is an active participant and the lead Canadian agent in major international particle physics programs, including the CERN Large Hadron Collider project in Switzerland and the T2K neutrino physics program in Japan. Collectively, more than 200 Canadian scientists work on these international projects.

- **Materials science**, including research into fields including high temperature superconductors, green chemistry, and hydrogen storage materials. Largely driven by UBC, Alberta and McMaster research, TRIUMF has developed one of only three μ SR Spectrometers in the world, along with the only depth-resolved β -NMR spectrometer in the world, allowing TRIUMF to undertake world-class research in these fields.

2.2. Study background and objectives

In order to continue and advance its research in these three fields, TRIUMF has proposed three capital projects for development over the next three to five years:

- **Nuclear medicine centre**, to provide dedicated lab space and a shielded cyclotron vault to further develop new potential opportunities in the fast-growing field of nuclear medicine. The new facility would meet the Good Manufacturing Practice standards established by Health Canada, to further facilitate the direct crossover of laboratory research into human trials. The cost for this 8,100 square foot facility is estimated at \$17.5 million.
- **Tier 1 data centre**, to house 8,000,000 gigabytes of data storage capacity to continue TRIUMF's role as one of 11 global centres receiving and warehousing data produced by the CERN Large Hadron Collider (LHC) project in Switzerland. Utilizing CANARIE and BCNET, this high capacity data centre will make LHC data available to scientists worldwide, but will also provide commercial opportunities for local industries that use large volumes of data (such as mining, biotechnology, and finance). The cost for this 18,000 square foot facility is estimated at \$12.5 million.
- **Advanced Rare Isotope Laboratory (ARIEL)**, to provide for the construction of a new underground beam tunnel and potential new linear accelerator facility (subject to federal funding) that will allow TRIUMF to better capitalize on existing investments in research capabilities, and broaden its research capabilities in material science and particle physics. The cost for this 24,450 square foot facility (and related underground tunnel infrastructure) is estimated at \$30.7 million.

The total cost for these three projects comes to \$60.7 million, and will provide the new infrastructure required for TRIUMF's proposed research directions over the next decade. TRIUMF is seeking support from the Provincial government to fund these capital projects, so as to maintain TRIUMF's position as Canada's premier particle and nuclear physics laboratory and to secure ongoing and enhanced federal funding for TRIUMF's operations.

Accordingly, TRIUMF has asked MMK Consulting to estimate the economic and social impacts of its operations upon the BC and Canadian economies, and how these impacts will change in the future with or without \$60.7 million in Provincial support for this new research infrastructure.

3. Economic Impact Analysis

3.1. Economic impact methodology

Expenditures by any business, institution or for any project give rise to a variety of impacts in the economy:

- Expenditures made by businesses, institutions or projects represent **direct economic impacts**. The most important impacts include total output, GDP (value added), employment, and government fiscal impacts (taxes collected).
- The expenditures made by businesses, institutions or projects also give rise to additional activity among the various suppliers of the business, institution or project. These **indirect economic impacts** help to compound the total economic impact of the original expenditures.
- In the course of operations, employees of both a business or institution and its suppliers also receive income, much of which they then spend on a variety of goods and services. This spending by employees represents **induced economic impacts**.

The methodology for this study has been designed to estimate the direct, indirect, and induced economic impacts generated by TRIUMF on the economy of British Columbia. This is less than the total economic impact of TRIUMF's operations, due to the fact that approximately 20% of TRIUMF's expenditures are purchased from suppliers outside of BC, and therefore do not generate economic impacts within BC.

Within this framework of direct, indirect, and induced economic impacts, a number of statistical considerations govern the best approach to analyzing economic impacts. These factors, and how they have been considered in this study, are as follows:

- **Opportunity cost** recognizes that certain expenditures, if not made, would be used in another way that also give rise to economic impacts.

With regard to construction, spending the \$60.7 million that is being sought from the Province for facility construction would generate economic impacts within BC estimated at \$105.3 million in output, \$44.0 million in GDP, and 543 FTE jobs. We have not included these economic impacts among the overall economic impacts attributable to TRIUMF because, if the Province chooses not to spend this money at TRIUMF, it would most likely deploy this money for some other purpose within the province. While the impacts of these alternate uses may differ, it would not be reasonable to count all of the economic impact of this expenditure as being incremental and attributable to TRIUMF.

With regard to operations, we have treated the full economic impacts related to TRIUMF's federal government operating funding as being incremental to BC. Given that TRIUMF is a unique facility within the province, if TRIUMF were to lose its federal support the funding would be redeployed by the Government of Canada to other institutions, most likely outside of British Columbia.

- **Social safety net** assumptions impact the magnitude of calculated economic impacts, particularly with respect to government tax revenues. A model with a social safety net assumes that any jobs created are filled by workers who were previously resident in BC and were receiving social assistance. A model with no social safety net assumes that any jobs created are filled by new entrants to the labour force, most likely moving to BC from outside the province. Given the highly specialized work undertaken at TRIUMF, and that about 40% of TRIUMF's scientific staff are from outside of Canada (with many more coming from other provinces within Canada), in this analysis we have applied a model that assumes no social safety net.
- **Open or closed model** relates to whether or not induced economic impacts should be counted. A closed model includes induced economic impacts related to employee spending, and is relevant when jobs created are new to the province, attract new workers, and therefore increase the overall level of personal spending within the province. Once again, this assumption is appropriate for TRIUMF given the highly specialized work undertaken at TRIUMF and the significant portion of TRIUMF's scientific staff who are recruited from outside of British Columbia.

In summary, the economic impact methodology used for this analysis:

- Does not include the economic impacts from spending the \$60.7 million sought from the Province of BC for construction of new facilities at TRIUMF.
- Assumes no social safety net, as workers are primarily from out-of-province.
- Considers direct, indirect, and induced economic impacts.

Within this model framework, the economic impacts generated by TRIUMF have been estimated based upon the following sources of information:

- Actual data on direct output, payroll, employees and taxes paid for TRIUMF's existing operations.
- TRIUMF management estimates on direct output, payroll, employees and taxes paid for expected future operations, under different scenarios.
- BC Provincial Economic Multipliers, which have been used for the estimation of additional impacts, including indirect and induced economic impacts.

Due to the short timeframe required by TRIUMF for completion of this initial assessment, we have used economic multipliers published by BC Stats as derived from the BC Provincial Input-Output Model (BCIOM), rather than running actual TRIUMF data through the BCIOM itself. This latter approach would result in some refinement of the estimates presented in this report, but should not result in dramatically different estimates.

The BC Provincial Economic Multipliers and BCIOM distinguish between different economic impacts for different types of industries and economic activities. Given the diverse nature of TRIUMF's activities, we have constructed weighted average multipliers for TRIUMF based on the actual activities of TRIUMF, as follows:

- 15% weighting has been given to the multipliers for the Chemicals industry, which includes pharmaceutical production, including the production of nuclear medical isotopes.
- 40% weighting has been given to the multipliers for the Professional, Scientific and Technical Services industry, reflecting the fee-for-service assistance that TRIUMF provides to a variety of businesses and agencies across Canada.
- 45% weighting has been given to the multipliers for the Non-Profit Education Institutions industry, reflecting TRIUMF's significant role as a university research facility.

3.2. TRIUMF economic impacts

3.2.1. Existing economic impacts in British Columbia

In estimating the economic impacts generated by TRIUMF, we have considered three primary sources of economic impact:

- The actual operation of the TRIUMF facility itself.
- The operation of the related MDS Nordion facility, which represents an independent operation, but which is dependent upon TRIUMF staff and in part upon the main TRIUMF cyclotron. MDS Nordion does not represent a supplier to TRIUMF, and so its activities are not captured as part of TRIUMF's indirect economic impacts. Rather, MDS Nordion drives additional direct, indirect and induced economic impacts that would not occur if not for the existence of TRIUMF.
- Conferences and visiting researchers hosted by TRIUMF on a frequent basis, which attract scientists from across Canada and around the world, and which result in tourist spending in the province. From 2004 to 2008 TRIUMF hosted a total of 34 conferences in BC, attracting more than 3,500 attendees. TRIUMF also typically hosts 10 to 15 visiting researchers on any given day. Overall, TRIUMF management has estimated that total tourist spending in BC related to TRIUMF conferences and visitors averages at least \$2.5 million per year.

Based on these three primary sources of economic impact, and the economic impact methodology described in the previous section, the estimated annual BC economic impacts attributable to TRIUMF's are summarized in Table 3.1 (overleaf).

Not surprisingly, TRIUMF's core operations are the largest driver of economic impacts, generating an estimated \$95.4 million in total annual output, \$58.4 million in total annual GDP, and creating a total of 832 FTE jobs. TRIUMF's core operations result in estimated annual Provincial revenues of \$5.7 million.

The existence of MDS Nordion also contributes significantly to the total economic impact of TRIUMF. MDS Nordion generates an estimated \$43.0 million in total annual output, \$18.0 million in total annual GDP, a total of 189 FTE jobs, and \$1.7 million in total annual Provincial revenues.

The economic impacts of TRIUMF’s conferences and visitors are far more modest, but are still estimated to generate \$2.0 million in GDP and sustain 48 FTE jobs.

Table 3.1
Estimated annual BC economic impacts attributable to existing TRIUMF operations and related direct activities

	Estimated Annual BC Economic Impacts			
	Direct	Indirect	Induced	Total
Output				
- TRIUMF operations	\$47.3M	\$24.1M	\$23.9M	\$95.4M
- MDS Nordion	\$25.0M	\$12.8M	\$5.3M	\$43.0M
- TRIUMF conferences & visitors	\$2.1M	\$1.2M	\$0.9M	\$4.2M
Total	\$74.5M	\$38.1M	\$30.1M	\$142.6M
GDP				
- TRIUMF operations	\$34.5M	\$10.5M	\$13.4M	\$58.4M
- MDS Nordion	\$8.5M	\$6.5M	\$3.0M	\$18.0M
- TRIUMF conferences & visitors	\$1.0M	\$0.5M	\$0.5M	\$2.0M
Total	\$44.0M	\$17.5M	\$16.9M	\$78.4M
Employment				
- TRIUMF operations	477 FTE	153 FTE	202 FTE	832 FTE
- MDS Nordion	90 FTE	55 FTE	44 FTE	189 FTE
- TRIUMF conferences & visitors	32 FTE	8 FTE	8 FTE	48 FTE
Total	599 FTE	216 FTE	254 FTE	1,069 FTE
Provincial revenue				
- TRIUMF operations	\$2.9M	\$0.7M	\$2.1M	\$5.7M
- MDS Nordion	\$0.8M	\$0.4M	\$0.5M	\$1.7M
- TRIUMF conferences & visitors	\$0.1M	\$0.0M	\$0.1M	\$0.3M
Total	\$3.8M	\$1.1M	\$2.7M	\$7.6M

3.2.2. Existing economic impacts in Canada

More than 90% of TRIUMF’s total Canadian economic impacts occur within British Columbia, where the research facility and the majority of staff are located. However, TRIUMF’s total economic impacts in Canada are somewhat larger than the BC impacts shown in Table 3.1 above, due to the existence of TRIUMF staff located outside of British Columbia, as well as purchasing from suppliers across Canada.

The total economic impacts for Canada from TRIUMF, MDS Nordion, and related activities amount to \$152.6 million in annual output, \$81.8 million in annual GDP, 1,112 FTE jobs, \$13.1 million in annual federal tax revenues, and \$7.9 million in annual provincial tax revenues (for all provinces).

3.2.3. Shorter term future economic impacts in British Columbia

Shorter term future economic impacts of TRIUMF have been estimated for the fiscal years from 2010/11 through 2014/15. This period aligns with TRIUMF’s next scheduled five year federal/NRC funding block. While this funding block has not yet been finalized, it is expected to vary based upon whether or not the proposed facility expansions at TRIUMF take place.

TRIUMF received \$225 million in federal/NRC funding for its current five-year funding block, from 2005/06 through 2009/10. TRIUMF management have estimated expected future federal funding for multiple funding scenarios, including – simply maintaining the existing facility, building any one or more of the three proposed new projects, or building all three of the proposed new projects:

- If TRIUMF completes all three proposed capital projects, expected five-year federal/NRC funding for 2010-2015 is estimated at \$328 million. This represents “Scenario A”.
- If TRIUMF does not complete any of the three proposed capital projects, expected five-year federal/NRC funding for 2010-2015 is estimated at \$203 million. This represents “Scenario D”, without any redirection to compensate for the lack of capital investment.
- Building any one or two of the three proposed capital projects is expected to result in a level of federal/NRC funding that lies between \$203 million and \$328 million.

If all three proposed capital projects proceed, an expansion of activity at TRIUMF can be expected, with total federal/NRC funding projected to increase by 46%. However, if none of the proposed capital projects proceed, then activity at TRIUMF can be expected to decline, with a projected drop of 10% total federal/NRC funding for the next five years.

To analyze the economic returns from investing \$60.7 million in construction of the proposed capital projects, we have determined the net incremental economic impacts between Scenarios A and D, to estimate the increase in economic impacts attributable to the decision to proceed with all three facility expansion projects.

Total estimated economic impacts attributable to TRIUMF operations under each of Scenarios A and D are detailed in Table 3.2 (overleaf), along with the net increase in economic impacts attributable to the facility expansion.

The proposed facility expansion projects at TRIUMF have a strong net positive economic impact on British Columbia – both preventing a decline from TRIUMF’s current levels of economic impact and generating strong increases in economic activity and impact when compared to the expected situation if the proposed facility expansions do not proceed. In particular, the investment of \$60.7 million is expected to result in:

- A net increase of \$125 million in federal/NRC funding for TRIUMF over the five years from 2010 to 2015, from \$203 to \$328 million.
- A net increase in total provincial GDP of \$31.3 million per annum (from \$50.9 to \$82.2 million), or \$156.5 million over five years.
- A net increase in total provincial employment of 373 FTE jobs (from 674 to 1,047).
- A net increase in Provincial tax revenues of \$3.1 million per annum (from \$5.0 to \$8.1 million), or \$15.5 million over five years.

Table 3.2
Estimated annual BC economic impacts attributable to future TRIUMF operations under alternate scenarios

	Estimated Annual BC Economic Impacts (TRIUMF operations only)			
	Direct	Indirect	Induced	Total
Output				
- Scenario A (expansion)	\$67.1M	\$34.2M	\$33.9M	\$135.2M
- Scenario D (no expansion)	\$41.5M	\$21.2M	\$21.0M	\$83.7M
Net attributable to expansion	\$25.6M	\$13.0M	\$12.9M	\$51.5M
GDP				
- Scenario A (expansion)	\$48.3M	\$14.9M	\$19.0M	\$82.2M
- Scenario D (no expansion)	\$29.9M	\$9.2M	\$11.8M	\$50.9M
Net attributable to expansion	\$18.4M	\$5.7M	\$7.2M	\$31.3M
Employment				
- Scenario A (expansion)	543 FTE	217 FTE	286 FTE	1,047 FTE
- Scenario D (no expansion)	362 FTE	134 FTE	177 FTE	674 FTE
Net attributable to expansion	181 FTE	83 FTE	109 FTE	373 FTE
Provincial revenue				
- Scenario A (expansion)	\$4.1M	\$0.9M	\$3.0M	\$8.1M
- Scenario D (no expansion)	\$2.5M	\$0.6M	\$1.9M	\$5.0M
Net attributable to expansion	\$1.6M	\$0.4M	\$1.2M	\$3.1M

Economic impacts related to MDS Nordion and TRIUMF conferences and visitors are not considered in Table 3.2, as in the shorter term these are not expected to vary based upon whether or not the proposed facility expansion proceeds. However, if the proposed facility expansion projects at TRIUMF do proceed, and impacts related to MDS Nordion and TRIUMF conferences and visitors remain similar to recent years, then Table 3.3 (overleaf) summarizes the estimated total annual BC economic impacts attributable to TRIUMF over the coming five years.

After adding the economic impacts related to MDS Nordion and TRIUMF conferences and visitors to the “Scenario A” impacts for TRIUMF operations, an expanded TRIUMF is estimated to drive a total of \$912 million in economic output in British Columbia between 2010 and 2015, delivering \$511 million in provincial GDP, \$50 million in provincial tax revenues, and supporting 1,284 FTE jobs.

Table 3.3
Estimated annual BC economic impacts attributable to TRIUMF operations and related direct activities, 2010-2015 under “Scenario A”

	Estimated Annual BC Economic Impacts				Five-Year Total
	Direct	Indirect	Induced	Total	
Output					
- TRIUMF operations	\$67.1M	\$34.2M	\$33.9M	\$135.2M	\$676.2M
- MDS Nordion	\$25.0M	\$12.8M	\$5.3M	\$43.0M	\$215.0M
- TRIUMF conferences & visitors	\$2.1M	\$1.2M	\$0.9M	\$4.2M	\$21.0M
Total	\$94.2M	\$48.1M	\$40.1M	\$182.4M	\$912.2M
GDP					
- TRIUMF operations	\$48.3M	\$14.9M	\$19.0M	\$82.2M	\$411.1M
- MDS Nordion	\$8.5M	\$6.5M	\$3.0M	\$18.0M	\$90.0M
- TRIUMF conferences & visitors	\$1.0M	\$0.5M	\$0.5M	\$2.0M	\$10.2M
Total	\$57.9M	\$21.9M	\$22.5M	\$102.3M	\$511.3M
Employment					
- TRIUMF operations	543 FTE	217 FTE	286 FTE	1,047 FTE	1,047 FTE
- MDS Nordion	90 FTE	55 FTE	44 FTE	189 FTE	189 FTE
- TRIUMF conferences & visitors	32 FTE	8 FTE	8 FTE	48 FTE	48 FTE
Total	666 FTE	280 FTE	338 FTE	1,284 FTE	1,284 FTE
Provincial revenue					
- TRIUMF operations	\$4.1M	\$0.9M	\$3.0M	\$8.1M	\$40.4M
- MDS Nordion	\$0.8M	\$0.4M	\$0.5M	\$1.7M	\$8.3M
- TRIUMF conferences & visitors	\$0.1M	\$0.0M	\$0.1M	\$0.3M	\$1.3M
Total	\$5.0M	\$1.4M	\$3.6M	\$10.0M	\$49.9M

3.2.4. Longer term future economic impacts in British Columbia

Longer term future economic impacts of TRIUMF are those that would occur after 2015.

TRIUMF management advise that the proposed facility expansions, and the expected related increase in federal/NRC funding, will help to keep TRIUMF on the leading edge of global particle and nuclear physics, and well positioned for ongoing future operations beyond 2015.

However, if the facility expansions do not proceed, TRIUMF management believe that by 2015 TRIUMF will have fallen behind the leading edge of global research. In science, there is no second place for the Nobel Prize, and no reward for repeating experiments already completed by others. Remaining on the cutting edge of science is vital to the long term existence of TRIUMF.

Without the facility expansions that are currently proposed, it is the opinion of TRIUMF management that 2015 would likely result in the development of a wind-down plan by NRC and TRIUMF. This would lead to the total loss of TRIUMF’s existing operations, and also result in the loss of MDS Nordion operations which are partially dependent upon TRIUMF personnel and infrastructure.

Therefore, the potential net longer term economic impacts based upon whether or not the proposed facility expansion proceeds appear to be much higher than the shorter term impacts, with the potential to lose \$78 million in existing annual provincial GDP and over 1,000 existing jobs if TRIUMF operations are wound up after 2015.

3.3. Limitation of results

The results presented in this report are subject to three significant limitations of which the reader should be aware:

- Estimates of future levels of TRIUMF funding and activity form a cornerstone of the analysis presented in this report. These estimates have been provided by TRIUMF management based on their experience and expertise in past dealings with the National Research Council. MMK Consulting has used these management estimates in good faith, but is not in a position to verify the accuracy of these estimates.
- Due to the short timeframe required by TRIUMF for completion of this assessment, we have used economic multipliers published by BC Stats as derived from the BC Provincial Input-Output Model (BCIOM), rather than running actual TRIUMF data through the BCIOM itself. This latter approach would result in some refinement of the estimates presented in this report, but should not result in dramatically different estimates.

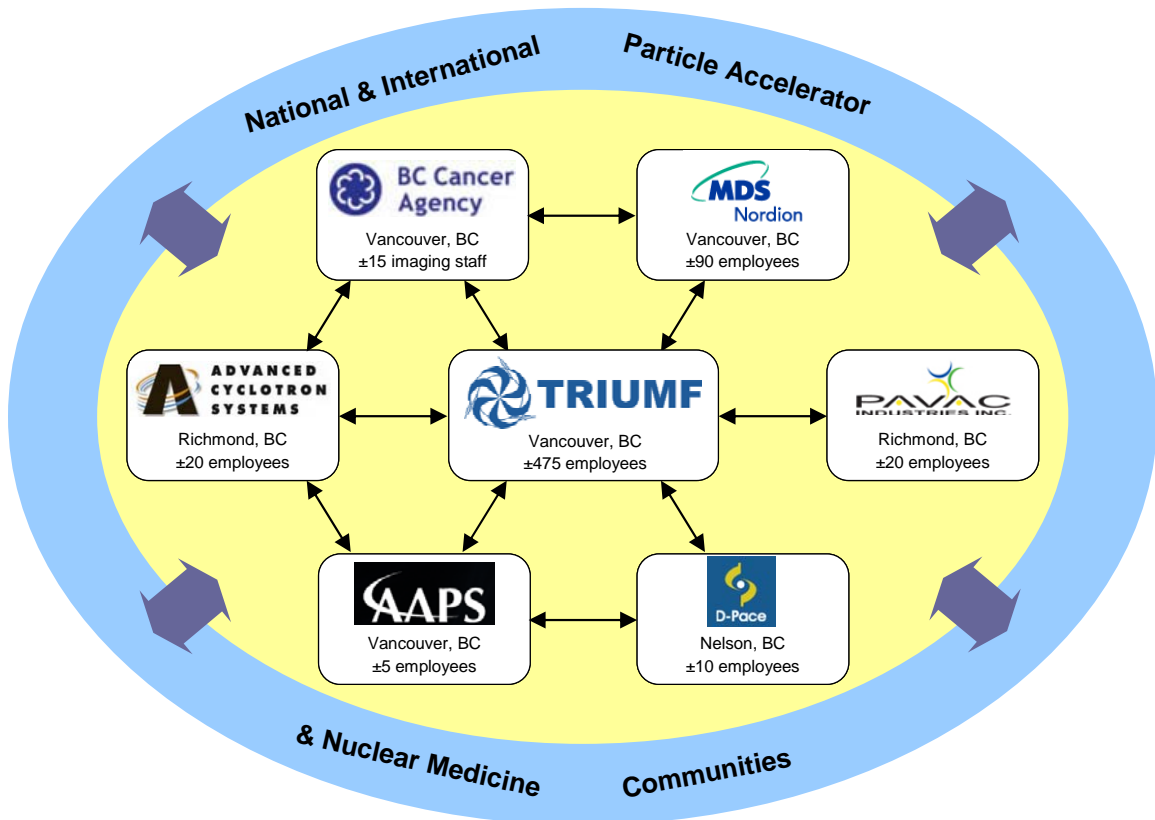
4. Socio-Economic Impacts

In addition to the economic impacts presented in the previous Chapter, there are also significant socio-economic impacts that arise from TRIUMF's existing and ongoing operations. While such impacts and benefits cannot be readily quantified, this Chapter presents a concise summary of some of the additional beneficial impacts that TRIUMF within the BC economy.

4.1. The heart of a growing advanced technology cluster

TRIUMF represents the heart of a growing advanced technology cluster in British Columbia, focusing on particle accelerator technology and its application in nuclear medicine. The key players in this cluster are illustrated in Exhibit 4.1, and are summarized below, with direct cluster employment exceeding 600 jobs. TRIUMF technology and/or technical knowledge is vital to the existing operations and/or future expansion plans of the businesses and agencies which comprise this cluster.

Exhibit 4.1
BC particle accelerator and nuclear medicine cluster



- **MDS Nordion** (Nordion) is an Ottawa-based company that is a world leader in the supply of diagnostic imaging and therapeutic isotopes. Nordion, TRIUMF and UBC have maintained successful collaborative partnerships for almost 30 years, resulting in the development of Nordion's commercial radioisotope production facility on the TRIUMF campus, utilizing TRIUMF-designed technology.

Since 2003, isotopes produced by Nordion at its TRIUMF facility have supplied the nuclear imaging and treatment needs of an estimated 45,000 patients per week. Products produced at this facility assist in the diagnosis and treatment of diseases including thyroid and prostate cancer, and cardiac and neurological disorders. Nordion employs approximately 90 staff in British Columbia, and exports approximately 95% of its isotope production.

In the growing field of radiopharmaceuticals, Nordion, TRIUMF and UBC are continuing their long-running collaboration to develop new radiopharmaceutical products. In these joint R&D initiatives, UBC researchers provide the core medical research capabilities, with TRIUMF contributing its expertise in radio-pharmacy and Nordion its expertise in product commercialization. While the development and approval process for new drugs can take years, a successful cancer therapy has the potential to generate a return of \$50-100 million.

- **BC Cancer Agency** (BCCA) is an agency of the Provincial Health Services Agency tasked with cancer prevention and screening, diagnosis, treatment, and care throughout the province.

Functional imaging plays a vital role in modern cancer diagnosis and treatment, assisting in the correct diagnosis and staging of the cancer, and then monitoring the ongoing effectiveness of treatment. PET-CT scanning has emerged over the last 10 years as the new "gold standard" of care for certain types of cancer. BCCA operates the only PET-CT scanner in the province, and more than 8,000 patients have benefited from this technology as part of their cancer treatment program since the scanner began clinical operation in June 2005.

To date, the Fluorine-18 (F-18) required for the PET-CT scanner has been supplied by TRIUMF and manufactured into the active FDG tracer by BCCA radio-chemists located at TRIUMF. Due to its short half-life, FDG is delivered twice a day from TRIUMF to BCCA. BCCA is now in the process of developing an in-house cyclotron to supply the required F-18 – but benefiting from TRIUMF designed technology. TRIUMF will continue to act as a backup supplier of F-18 as required, and will also provide advanced technical support to BCCA. Ongoing collaborative research between BCCA and TRIUMF in functional imaging and radiochemistry is also envisaged.

- **Advanced Cyclotron Systems** (ACS) is a Richmond-based firm which manufactures, markets, installs, and services TR cyclotrons – a design originally developed by TRIUMF in the 1980s. ACS cyclotrons are developed and installed for commercial purposes. ACS supplies university, medical, and industrial customers around the world, including MDS Nordion and the BC Cancer Agency. ACS employs approximately 20 staff in British Columbia.

- **PAVAC Industries** (Pavac) is a Richmond-based manufacturer and service provider for electron-beam welding equipment and related technologies.

Pavac's relationship with TRIUMF is relatively recent, and started with Pavac being selected as a local supplier capable of fabricating specialized solid niobium superconducting cavities required by TRIUMF. Pavac's electron beam welding technology – itself a form of particle acceleration – was able to meet the high-precision welding requirements for this contract. Having established this capability with TRIUMF, Pavac has also identified export potential for the production of superconducting cavities.

Based on this successful first interaction, in early 2006 Pavac began a collaborative development project with TRIUMF related to increasing energy levels and proving reliability for electron beam flue gas treatment (EBFGT) systems. EBFGT systems can provide multi-pollutant emission reduction for coal-fired power plants at a lower cost than alternate technologies. Pavac has now secured a \$75 million contract for the design, manufacture, and installation of this technology in a single power plant, and Pavac estimates that more than 50,000 coal fired plants in the world could benefit from this technology.

Pavac currently employs approximately 20 people in British Columbia, but expects to double this number by 2010 due to new contract opportunities, and further expects to grow to 200 people within 10 years.

- **D-Pace** is a TRIUMF spin-off company based in Nelson, BC. D-Pace supplies both engineering services and beam line and target equipment for use with cyclotrons, linear accelerators and ion implanters.

The CEO of D-Pace, Dr. Morgan Dehnel, is a former TRIUMF researcher and started D-Pace after leaving TRIUMF in 1995. D-Pace originally provided consulting engineering services related to particle accelerators, but since 2001 has been designing and selling custom equipment based on technologies licensed from TRIUMF. D-Pace products and services have been sold to customers around the world. The company now has sales in excess of \$1 million per year, and workforce equivalent to approximately 10 FTE employees.

- **Advanced Applied Physics Solutions** (AAPS) is a not-for-profit corporation established by TRIUMF and funded by \$15 million in seed funding from the federal Networks of Centres of Excellence program as a Centre of Excellence for Commercialization and Research.

The objective of AAPS is to establish a team dedicated to the commercialization of innovative TRIUMF research, by actively seeking out partners for late-stage research and commercialization. This proactive approach to commercialization is intended to enhance and accelerate the economic benefits (including financial returns) flowing back into BC from TRIUMF research.

AAPS commenced operations in 2008, and currently represents a team of five employees. However, AAPS expects to expand this team to approximately 15 by early in 2010.

The Nuclear Medicine Laboratory and ARIEL Beam Tunnel proposed for construction by TRIUMF will directly support and enhance the types of research that are relevant to further building and advancing these cluster partnerships.

4.2. Leading Canada's role in global "big science"

The science of particle physics is often referred to as global "big science". World-leading particle physics research is characterized by large international research collaborations, large research budgets, and increasingly larger equipment used to study increasingly smaller aspects of sub-atomic matter. "Big science" is seeking answers to fundamental issues such as the mechanisms of the big bang, the dominance of matter over anti-matter in the universe, and the possible existence of parallel dimensions of time and space.

As Canada's national laboratory for particle and nuclear physics, TRIUMF leads Canada's role in major international "big science" research collaborations. This involvement keeps local scientists at the forefront of global science, attracts highly qualified personnel to British Columbia to live and work, and provides opportunities for domestic firms to participate in the fabrication and supply of equipment and apparatus required by these global projects.

Major international collaborations active at this time include:

- **CERN Large Hadron Collider:** The Large Hadron Collider (LHC) project being developed by CERN underneath Geneva, Switzerland, represents the world's largest particle accelerator and collider, and the largest scientific device ever built. The 27 kilometre circumference of the LHC is more than four times larger, and supports energy levels seven times higher, than any previous device.

Canada's contributions to the LHC project are being led by TRIUMF, and have included the design, fabrication, and testing of key measurement apparatus, as well as housing one of 11 global data centres for receiving and warehousing data produced by the LHC. This data centre is housed at TRIUMF and capitalizes upon the significant investments made by the federal and provincial governments in CANARIE and BCNET. Expansion of this data centre represents one of the three capital expansion projects proposed by TRIUMF at this time.

- **Tokai To Kamioka Neutrino Project (T2K):** This Japanese-led project involves approximately 150 collaborating scientists from 53 institutions in 12 countries, including Canada. The project is developing a second generation long-baseline neutrino-oscillation experiment using a 295 kilometre beam line. Like the LHC, Canada's contributions to the T2K project are being led by TRIUMF, and have included the design, fabrication, and testing of key measurement apparatus.
- **Canadian Spallation Ultracold Neutron Source (CSUNS):** This represents a collaborative project between Canada, Japan and the United States to construct the world's highest density source of ultracold neutrons at TRIUMF. This project will lead to ongoing experimentation at TRIUMF by international researchers utilizing the CSUNS.

These major projects also help to generate smaller international collaborative projects between organizations that connected as a result of the major international projects. For example, TRIUMF recently signed a Memorandum of Understanding (MOU) for joint research activities in nuclear medicine with the Variable Energy Cyclotron Centre (VECC) in Kolkata, one of India's leading atomic research centres. This MOU also leverages the partnership between TRIUMF and PAVAC Industries of Richmond (refer Section 4.1), and includes funding from India for apparatus to be designed by TRIUMF, manufactured by Pavac, and shipped to India.

4.3. Developing technologies relevant to British Columbia

The research being conducted at TRIUMF primarily represents basic research into questions of fundamental physics. However, this basic research also generates applied research relevant to a variety of social and industrial applications.

In 2007-8, TRIUMF reported eight new novel disclosures with commercial potential, applied for families of patents on five discoveries, and was granted patents on eight discoveries from earlier years. TRIUMF now has 11 technologies that it has licensed for commercial development, and earns approximately \$2 million per year from commercial services, including technology licensing and consulting.

Ongoing research at TRIUMF includes the following applied research projects that have the potential to be of significant practical benefit to British Columbia, Canada, and Canadian industry. These projects represent only a small sample of relevant, applied research programs being undertaken at TRIUMF:

- Among the numerous **healthcare** projects underway at TRIUMF, a major project is seeking to develop a production process for Molybdenum (Moly-99) medical isotopes using linear accelerators. This process has the potential to solve two major problems:
 - Establishing an alternative supply of Moly-99 for domestic and global nuclear medicine programs in addition to the aging and troubled Chalk River reactor in Ontario, without the need to build a new nuclear reactor.
 - Providing a process for creating Moly-99 from non-enriched uranium, rather than the weapons grade uranium used in Chalk River. This change would improve Canada's compliance with nuclear non-proliferation treaties.

This project expects to have a functional prototype within 12 months of starting, and the potential for full manufacturing in partnership with industry within 24 months.

Other healthcare research projects underway at TRIUMF are seeking advancements in the treatment of diseases including Parkinson's, diabetes, Alzheimer's, and various forms of cancer.

- In terms of **environmental** protection and remediation, TRIUMF is involved in a variety of research projects, including:
 - Using copper radioisotopes produced by TRIUMF and MDS Nordion to analyze the absorption of CO₂ by marine phytoplankton, and to seek ways to increase the already-significant levels of CO₂ absorbed by these plants.
 - Using nitrogen radiotracers produced by TRIUMF to analyze the transport of nitrate in crop plants, with the objective of optimizing fertilizer constituents and reducing overall fertilizer usage.
 - Working with Richmond-based PAVAC Industries to increase energy levels and prove reliability for electron beam flue gas treatment systems, which can provide multi-pollutant emission reduction for coal-fired power plants.

- In terms of **natural resources**, TRIUMF is involved in a number of research projects, including:
 - Using radiotracers and PET imaging techniques on wood fibres with the objective of improving the fluid dynamics associated with papermaking. This has potential to improve the efficiency of BC paper mills and to reduce the large volumes of water required in the papermaking process.
 - The high capacity data centre being developed by TRIUMF, the expansion of which represents one of TRIUMF's three proposed capital projects, is providing TRIUMF with research and collaboration opportunities in data processing and analysis for data-intensive industries. The BC mining industry is expected to benefit from this new capability, providing improved processing and interpretation of geological data.
- TRIUMF's proton and neutron irradiation facility (PIF/NIF) provides the capability to test **electronics** and **aerospace systems** in simulated atmospheric conditions, with the capability to simulate years of atmospheric exposure in a matter of minutes. TRIUMF and the Los Alamos Neutron Science Center in New Mexico are the only two facilities in North America to offer such a wide range of neutron test energies. As a result, the TRIUMF facility attracts commercial researchers from a wide range of global aerospace and electronics firms.

4.4. The return from investing in knowledge

Investments in knowledge are proven to generate strong returns in the local economy. Across a full range of 25 industries analyzed by BC Stats in its *BC Provincial Economic Multipliers (2008)*, investments in education rank fifth among 25 industries for generating total output, and first among 25 industries for converting that output into both GDP and jobs.

The returns from government investments in knowledge development can be also be amply demonstrated from successes in other jurisdictions, including:

- **Singapore** identified a need to develop a life science industry in the mid 1990's and in 2000 launched its Biomedical Sciences Initiative with a government investment of US\$2 billion over five years. By focusing this investment on research facilities (including six research institutes housed in the 2 million square foot Biopolis complex), highly qualified personnel (one third of researchers in Singapore are foreigners) and R&D projects, Singapore has been able to build an impressive biomedical industry from scratch. By 2005, the biomedical sector employed 10,200 people and biomedical manufacturing output topped US\$7.2 billion. Output grew by 40% between 2004 and 2006. By 2008, five of the world's major pharmaceutical companies were operating in Singapore, along with hundreds of smaller pharmaceutical and biotech firms.
- **Ireland** invested heavily in education and knowledge as a key part of its radical economic transformation in the 1990's. Between 1980 and 2000 the number of students in Irish universities and colleges tripled, with a focus on technical skills, science, engineering, and business. By 2000, Ireland had a significantly higher proportion of science and engineering graduates in its young adult population (20-34 years) than the UK, Japan, the US or Germany. The results of the Irish economic revolution speak for themselves: 72% growth in employment from 1990 to 2005 and an unemployment rate well below the EU average.