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ANDERSON ECONOMIC GROUP

The Economic Impact of Fermi National Accelerator Laboratory

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I. Executive Summary

PURPOSE OF REPORT

Fermi National Accelerator Laboratory (Fermilab) is a basic science research facility specializing in high-energy particle physics. The laboratory is located 35 miles west of Chicago near Batavia, Illinois. Fermilab is one of 17 national laboratories owned by the U.S. Department of Energy. As a national laboratory, Fermilab receives most of its funding from the federal government. However, the lab is administered by Fermi Research Alliance, a limited liability company formed by the University of Chicago and the Universities Research Association. The purpose of this report is to produce a credible and conservative estimate of the economic impact of Fermilab's operations on the Chicago region and the state of Illinois as a whole.

OVERVIEW OF APPROACH

In this report we estimate the local economic impact of Fermilab's operations and its contributions to basic scientific research. We discuss key features of our methodology below.

Economic Impact Defined. Economic impact is the measure of *net new* economic activity that occurs in a defined geographic region as a result of an investment, event, project, industry, or institution. A direct economic impact stems from the initial spending or investment while an indirect economic impact stems from the recirculation of dollars within the defined region. In this report, we measure economic impact in terms of 1) total new economic activity, 2) earnings to workers, and 3) number of jobs created or supported.

Approach to Estimating Fermilab's Economic Impact. We estimated the impact of Fermilab in two geographic regions: 1) the Chicago metropolitan region, which includes an eight-county area in Illinois,[1] and 2) the entire state of Illinois. We were careful to count *only* the portion of federally-funded expenditures that occurred in these geographic regions that would not have occurred in the region without Fermilab's presence. We also considered alternative uses of the land that Fermilab currently occupies. Fermilab is built on the remains of a small village, surrounded by western suburbs of Chicago and several small forest preserves and parks. West of the site the land rapidly turns into farmland and small towns. We assumed that in Fermilab's absence the site would probably be a small suburban community, but not a commercial center or creator of many jobs for the region. Since we limit the expenditures we count and consider alternative land uses, our estimate of economic impact is conservative and credible. See "Appendix A. Data and Methodology" on page A-1 for a complete description of our economic impact analysis.

1. The Chicago region includes the counties of Cook, DeKalb, DuPage, Grundy, McHenry, Will, Kane, and Kendall.

ABOUT FERMILAB

Fermilab began as the National Accelerator Laboratory in 1967. The laboratory was renamed Fermi National Accelerator Laboratory in 1974 after Enrico Fermi, a Nobel-prize winning physicist. Fermilab is part of a network of national laboratories at which the world's top scientists and engineers can use the most technically-advanced equipment and facilities in order to carry out research. Fermilab's site includes 355 buildings with 2.3 million total square feet of floor space where scientists study high-energy physics. See "Overview of Fermilab's Operations and Basic Science Research" on page 5.

OVERVIEW OF FINDINGS

Fermilab makes significant economic and research contributions in Illinois. We report the results of our analysis in this section.

1. Fermilab is Responsible for Over 4,500 Jobs in Illinois.

Fermilab employed 1,942 full-time equivalent employees last year. Another 1,000 researchers were on-site to use Fermilab's facilities. Due to the lab's expenditures that went to businesses located in Illinois, and the expenditures of users of Fermilab facilities, we estimate another 2,587 jobs were indirectly created for a total of 4,529 jobs. Fully 87% of these jobs were in the eight-county Chicago region.

2. Fermilab Generated $643 million in Net New Earnings for Households and Businesses in Illinois in FY 2010.

We estimate that the total impact of Fermilab's operations was $643 million in economic output in Illinois in FY 2010. This accounts for almost half (44%) of Fermilab's expenditures going to businesses and individuals located outside Illinois and therefore not contributing to economic activity in the state. We estimate that 90% of the economic impact in Illinois goes to households and businesses in the Chicago region. See Table 1 below.

TABLE 1. Fermilab Economic Impacts in Illinois and Chicago Region

	Economic Output	Earnings	Employment
Chicago Region	$584,312,239	$173,142,302	3,962
State of Illinois (includes Chicago Region)	$643,040,542	$196,619,564	4,529

Data Source: Fermi National Accelerator Laboratory
Analysis: Anderson Economic Group, LLC

3. Research at Fermilab is Helping to Answer Questions about the Basic Laws that Govern the Universe.

Basic science is the foundation of technological advancement, even when researchers do not have specific applications in mind for their research findings. For example, early researchers of electromagnetism and quantum mechanics

would be surprised today to see the computers, wireless internet connections, and mobile phones that came from steady advancements built on their original work. Fermilab plays an important role in providing basic science research and supporting work that is difficult to accomplish in a university or private setting. Fermilab provides science infrastructure in the form of specialized equipment, instrumentation and experience. The most well-known of Fermilab's equipment is the Tevatron, which was the highest-energy particle accelerator in the world from 1983 to 2010. Fermilab is also home to the most intense and highest-energy neutrino beam in the world. This allows scientists to perform experiments on neutrinos, nearly massless particles that are common in the universe but difficult to observe. This infrastructure allows Fermilab scientists to observe new phenomena that provide clues about the nature of mass, dark matter, and other important topics. See "Contributions to Basic Science Research" on page 8.

4. Fermilab Scientists are Collaborating with Scientists at Other Institutions and in Private Industry to Advance Science and Develop Accelerator Technology.

Fermilab is working with scientists from all over the world. In FY 2010, Fermilab hosted 2,300 outside researchers with the majority visiting on-site. These visitors came from 42 countries. Fermilab is also serving as a primary facilitator and coordinator (for researchers from the United States) of access to the Large Hadron Collider (LHC) particle accelerator located in Switzerland. Throughout the design and construction of the LHC, Fermilab has been a partner of U.S. collaborators on LHC experiments.

Fermilab's research equipment needs have led to collaborations with private companies that have had spillover benefits for other industries. For example, Fermilab's need for large amounts of superconducting wire in the early 1970's helped the industry to expand and achieve improvements that allowed the wire to be produced at a much lower cost—an important factor in enabling the medical imaging industry to develop. Currently, Fermilab is working with companies like Pavac Industries, Inc., Euclid TechLabs, and Tezzaron Semiconductor to develop products suitable for use in particle physics research. See "Fermilab Collaborations" on page 20.

Fermilab has plans for an important new facility that will provide space and technical expertise for its own scientists and scientists from Argonne National Laboratory, universities, and private companies. The facility is called the Illinois Accelerator Research Center and is being developed with the Illinois Department of Commerce and Economic Opportunity and the U.S Department of Energy. All 86 institutions that are part of the Universities Research Association will have access to the facility.

5. Fermilab is Helping to Train the Next Generation of Scientists.

Fermilab is contributing to the development of the nation's scientists by providing information, inspiration, and research opportunities for K-12 students, college, and graduate students. In 2008 and 2009, about 18,000 K-12 students participated in activities and courses at Fermilab and another 12,000 students received visits in their classrooms by a Fermilab staff member. Fermilab has approximately 90 internships each year for U.S. and international college students. The most direct way that Fermilab contributes to the pipeline of scientists is by working with graduate students. Since 1972, over 1,600 PhDs have been received by Fermilab researchers. See "Fermilab's Contribution to the Science Pipeline" on page 22.

ABOUT ANDERSON ECONOMIC GROUP

Anderson Economic Group, LLC offers research and consulting services in economics, finance, market analysis, and public policy. Since AEG's founding in 1996, the company has helped clients including universities, state and local governments, non-profit organizations, and private and public companies. AEG has completed economic impact studies for universities located throughout the United States. For more information on the report's authors, please see "Appendix B. About the Authors" on page B-1.

II. Overview of Fermilab's Operations and Basic Science Research

In this section, we first present a brief history of Fermilab, and how its capabilities have evolved over the past 40 years. We also discuss the importance of basic science research for technological advances, and describe Fermilab's crucial role in furthering basic scientific knowledge. Next, we discuss the many experiments currently going on at Fermilab, all using particle accelerators or detectors in different capacities to better understand the nature of matter, space, and time.

BRIEF HISTORY

On November 21, 1967, President Lyndon B. Johnson signed a bill into law approving the construction of a National Accelerator Laboratory, a project commissioned by the U.S. Atomic Energy Commission. Construction on the laboratory's first permanent building began a little over a year later near Batavia, Illinois, about 35 miles west of Chicago. The laboratory would be renamed Fermi National Accelerator Laboratory, or Fermilab, in 1974, after Enrico Fermi, a Nobel Prize-winning physicist most renowned for producing the world's first controlled, self-sustaining nuclear chain reaction. The Universities Research Association (URA), a consortium of leading research universities, oversaw the operations of Fermilab until 2006, when the URA teamed up with the University of Chicago to form the Fermi Research Alliance. The Fermi Research Alliance continues to oversee the operations of Fermilab today.

Over the course of its first decade, the site became home to the most advanced network of particle accelerators at the time. Physicists use particle accelerators in order to create high-energy collisions between subatomic particles. In the aftermath of these collisions, scientists are able to observe some of the most fundamental particles in the universe. The initial layout at Fermilab was a series of four accelerators—a pre-accelerator, a linear accelerator (linac), a "booster," and a main ring. Each accelerator would speed up particles and inject them into the next accelerator, until the particles reached energies of 200 GeV (GeV is short for giga-electron volts, equivalent to one billion electron volts).[2] A beam of particles at this energy was first achieved in March 1972. Energy levels of 300 GeV were achieved just two months later.

In conjunction with these achievements, the first experiments at the site, including a 15-foot bubble chamber, were erected. (Bubble chambers are containers of liquid fine-tuned to react with particles. When a subatomic particle enters the chamber, it leaves a stream of bubbles, allowing scientists to observe the parti-

2. Electron volts are a measure of energy often used in particle physics. For example, a proton traveling with an energy of 1 GeV has a speed of about 100 billion meters per second, or 230 million miles per hour. Lighter particles travel even faster at this energy.

cle's path.) These initial projects were part of the fixed target program, constructed throughout the 1970s, and used for observing different types of subatomic particles, including mesons, neutrinos, protons, and pions.

By 1983, renovations to the series of accelerators increased the energy capabilities of Fermilab to 512 GeV, a record at the time. The main ring became known as the Energy Doubler/Saver. Eventually, it would adopt the name Tevatron, after attaining energies of 1 TeV (tera-electron volts, or 1,000 GeV). In 1986, particle collisions inside the Tevatron achieved a maximum energy of 1.8 TeV.

Two of the most famous discoveries at Fermilab include the first observation of the "bottom" quark at the fixed target Proton Center in June 1977 and the first observation of the "top" quark at the CDF and DZero detectors in 1995. (Different types of quarks combine to form protons, neutrons, and other particles. For more information on the CDF and DZero detectors, see "The Tevatron" on page 8). In addition, the most recent fundamental particle to be discovered is called the tau neutrino. It was first observed by scientists at Fermilab in July 2000.

The most recent addition to the accelerator complex at Fermilab is the Main Injector, a large ring adjacent to the Tevatron that acts as both a neutrino source and an intermediary between the booster and the main ring. The Main Injector accelerates particles from 8 GeV to 120 GeV before passing them on to the Tevatron. Construction on the Main Injector began in 1993 and was completed in 1999.

FERMILAB'S SCOPE AND ROLE

In 2010, Fermilab had 1,942 full-time equivalent employees (FTEs), as well as 391 visiting scholars and researchers with long-term appointments. There were also 670 undergraduate and graduate students working as researchers and research assistants at the site. Over the course of the year, 2,300 people from universities, research institutions, private companies, and government agencies used Fermilab's unique facilities.[3] The Fermilab site includes 355 buildings with 2.3 million total square feet of floor space. These facilities and other structures at the laboratory are worth an estimated $1.6 billion.

Since its inception, Fermilab has been part of a network of national laboratories at which the world's top scientists and engineers can use the most technologically-advanced equipment and facilities in order to carry out research. In total, the U.S. Department of Energy (DOE) owns 17 national laboratories throughout the country. Of these, ten labs, including Fermilab, are overseen by the DOE Office of Science. The national laboratories work together to encourage collab-

3. Number of users is based on data provided by Fermilab. The average length of an on-site visit for a user is 501 days.

oration in the scientific community and to design and construct new scientific and technical research facilities. Of these labs, Fermilab is the only facility designated exclusively for research on particle physics through the use of accelerators and accompanying advanced diagnostics.

THE IMPORTANCE OF BASIC SCIENCE RESEARCH

Fermilab contributes to American science and engineering through provision of science infrastructure in the form of specialized equipment, instrumentation, and experience, and through its staff's own work on basic science. "Basic science" is a term commonly used to refer to research that advances human knowledge without a specific, immediate application in mind. Such research adds to the body of scientific knowledge available to later scientists, engineers, entrepreneurs, and policymakers as they work to address national priorities, improve their company's productivity, or invent a new product.

Fermilab has an important role in providing basic science research and support that would be difficult to perform at a research university and virtually impossible in a private setting. Though scientists, engineers, and entrepreneurs working on *applied* science and engineering provide innovations that directly improve our economy and day-to-day lives, *basic* science advancements provide the necessary foundation for these innovations. For example, electronics and computer engineers that have made rapid, steady advancements and formed billion-dollar industries are standing on the shoulders of the scientists who advanced the basic science of electricity and quantum mechanics.

When there are advances in basic science, the original scientists are often unaware of potential future applications of their work. Imagine the surprise it would give early researchers of electromagnetism and quantum mechanics to see the computers, wireless Internet connections, and mobile phones in wide use today, all from steady advancements built on their original work. Indeed, it is rare that a particular product, efficiency improvement, or technical solution can be easily traced back to an individual scientific paper.

Due to the time-intensive and costly nature of advanced science and the unpredictability of returns, basic science cannot usually compete with the other investment options available to private companies and other investors. The gains of this research can be quite large, but even predictable gains are not easily captured by their inventor. Basic science is often considered by economists to be under-provided by the private sector, given its benefits and costs, for two reasons. First, once basic science research is published this knowledge passes to others. As a result, whoever paid for the research to be performed cannot charge people for its use. Second, if one person uses a scientific idea or theory, it does not prevent others from doing so. As a result, there is never a "scarcity" of the idea, and therefore no need, from a social perspective, to set a price to restrict allocation of the idea's use.[4]

CONTRIBUTIONS TO BASIC SCIENCE RESEARCH

The following is a list of the more prominent experiments taking place at Fermilab or in collaboration with Fermilab scientists. First, we look at the accelerators at Fermilab, followed by several experiments involving neutrinos, and finally we describe several Fermilab collaborations in the search for dark matter and dark energy in the universe.

The Tevatron

From 1983 until 2010, when its energy levels of nearly 2 TeV were surpassed by the LHC, the Tevatron was the highest-energy particle collider in the world. The Tevatron accelerates and stores beams of protons and antiprotons. These beams travel in opposite directions around an underground ring four miles in circumference at almost the speed of light before colliding at the center of two separate detectors. The detectors, called the Collider Detector at Fermilab (CDF) and DZero, contain many subsystems of detectors that identify different types of particles emerging from the collisions. Scientists explore the structure of matter, space, and time by analyzing the showers of particles created in these collisions.

The two detectors, CDF and DZero, are each about 5,000 tons, four stories tall, and house over 1 million individual detector elements. They are located at two different points along the Tevatron, and the particle beams cross paths an average of 1.7 million times per second at each detector. Each crossing presents an opportunity for one or more collisions between circulating protons and antiprotons. Physicists at both detectors record approximately 400 noteworthy collisions per second.

After more than 26 years of operation, the Tevatron will shut down in September of 2011. Physicists will continue to analyze the large dataset from the CDF and DZero experiments in the coming years.

The Large Hadron Collider (LHC)

After Fermilab stops collecting data from the Tevatron, new data from the Large Hadron Collider in Switzerland will open new avenues for exploration. Throughout the design and construction of the LHC, Fermilab has been a partner of U.S. collaborators on LHC experiments. Fermilab's Remote Operations Center and Grid Computing Center provide access to the LHC's collision data

4. In economics terms, basic science is a "public good" that is "non-excludable" (you cannot stop people from using a published idea) and "non-rival" (one person's use of the idea does not diminish others' ability to use it). For some ideas with immediate commercial applications, governments get around these challenges by awarding a temporary monopoly on the idea's use in the form of a patent or copyright. Basic science does not use intellectual property policy to encourage idea generation because the ideas are often quite far away from commercial exploitation, and because the world of science has developed a culture of openness that is considered extremely important for allowing ideas and data to be critiqued and examined, and ensuring that science advances with transparency and rigor.

for the roughly 1,000 scientists from U.S. institutions that collaborate on the Compact Muon Solenoid (CMS) experiment. (CMS is a detector at the LHC.)

Fermilab made significant contributions to the CMS detector during construction, installation, and preparation for collecting data, and is playing a lead role in developing ongoing upgrades to the CMS detector. Fermilab also analyzes data, develops software, and mentors hundreds of graduate students and young scientists for LHC projects.

During the construction of the LHC, Fermilab, in collaboration with CERN and the High Energy Research Organization (KEK) of Japan, designed and built the magnet systems that focus the beams in order to increase the frequency of collisions at LHC. Fermilab and Lawrence Berkeley National Laboratory designed and constructed eight cryogenic and power-feed boxes that also support the beam-focusing systems in the LHC. Fermilab is currently developing superconducting technologies that will be used in upcoming LHC upgrades.

Project X

The proposed Project X will be a high-intensity proton accelerator, with the potential to support several experiments at Fermilab. It will be the world's most powerful source of high-energy neutrinos, one of the lab's primary subjects of research (see "Neutrino Research" below). Project X would also be able to produce the world's highest-intensity beams of several other subatomic particles, including muons, kaons, protons, and low-energy neutrinos. The proposed project will use superconducting radio frequency (RF) cavities, a newly developed technology that has the ability to more efficiently accelerate particles. Superconducting RF cavities have potential applications in material development and nuclear energy, and Fermilab continues to collaborate with industry and other national laboratories on the research and development of this new technology.

Neutrino Research

Neutrinos are nearly massless particles that are extremely common in the universe. Trillions of neutrinos, traveling at nearly the speed of light, pass through the Earth and everything on it every second. Neutrinos tend to interact very weakly with other particles and they have no electric charge, making them difficult to observe. Current research on neutrinos focuses on determining the mass of different types of neutrinos, understanding how neutrinos oscillate between these types, and testing the symmetry of neutrino and anti-neutrino behavior.

Fermilab is home to the most intense and highest-energy neutrino beam in the world. The laboratory uses two neutrino sources, the Main Injector and the Booster, to generate neutrinos. The four active neutrino experiments at Fermilab are:

1. **Main Injector Neutrino Oscillation Search (MINOS).** In the late 1990s, scientists discovered that neutrinos could oscillate, or change between types. Dif-

ferent types of neutrinos interact differently with other particles. Scientists at Fermilab observe the nature of this oscillation by looking at a neutrino beam as it passes through two separate detectors. The near detector is located 330 feet underground at Fermilab, and the far detector is deep underground in a mine in Soudan, Minnesota, 450 miles away. Since neutrinos are so difficult to detect, this distant detector must be particularly sensitive. Its placement underground eliminates naturally-occurring background radiation from the atmosphere.

2. **Booster Neutrino Experiment (BooNE).** The goal of this experiment is to accurately measure the mass of a neutrino by observing the elusive particle and its opposite, the anti-neutrino. In the process, BooNE tests the theory that these two particles have identical mass. The main detector at BooNE, the 800-ton **MiniBooNE**, observes light emitted from collisions between neutrinos and electrons or between neutrinos and muons.
3. **Main Injector Experiment for ν-A (MINERνA).** Located 330 feet underground next to the near detector of the MINOS experiment, this detector captures, with unprecedented detail, collisions between low-energy neutrinos and the nuclei of atoms of carbon, iron, or lead. Having had success in observing these interactions at low energies, Fermilab scientists are now making observations of higher-energy neutrinos at MINERνA.
4. **Argon Neutrino Teststand (ArgoNeuT).** This experiment is expected to be a stepping-stone to a new generation of advanced neutrino detectors that use liquid argon. Like the bubble chambers of early particle physics research, this detector allows scientists to re-create the three-dimensional path of neutrinos and anti-neutrinos by observing the tracks they leave in their wake as they pass through the liquid argon.

Future Neutrino Research. The following neutrino experiments, intended to either expand upon current research or open new avenues of research, have been proposed or are in the process of development.

- Starting in 2013, Fermilab scientists will begin collecting data from the **NuMI Off-axis v-e Appearance Experiment (NOνA)**. The experiment will examine how neutrinos oscillate between types by using two detectors: a 220-ton detector near the beam source at Fermilab and a 15,000-ton detector located 500 miles away in Ash River, Minnesota.
- To build on the MINOS experiment, scientists have begun work on the **Long-Baseline Neutrino Experiment (LBNE)**, which would build the world's largest neutrino detector. The proposed site for the detector is the Homestake mine near the Black Hills National Forest in South Dakota, 750 miles from Fermilab.
- Some potentially anomalous results from MiniBooNE have led researchers at Fermilab to develop a proposal for a more advanced, more sensitive detector called **MicroBooNE**, which will be a liquid argon chamber, much like ArgoNeuT.

Astrophysics Research

Recent scientific evidence has suggested that only about 3% of the mass in the universe consists of matter, or stuff—everything that we can see. The nature of

the remaining 97%—called dark matter—remains a mystery. One possible explanation for this is the existence of weakly interacting massive particles (WIMPs). No WIMPs have ever been observed, and, according to theory, they should interact with other particles very rarely (which would explain why we cannot see them). Fermilab has several active experiments to try to detect WIMPs.

- The **Chicagoland Observatory for Underground Particle Physics (COUPP)** is an experiment that uses a bubble chamber placed underground at the Fermilab site, by the near detector in MINOS, to detect the presence of WIMPs.
- A separate device, used by the **Cryogenic Dark Matter Search (CDMS)**, is placed at the far detector in MINOS, deep in the Soudan mine in Minnesota. This device uses silicon and germanium plates at extremely low temperatures to look for WIMPs.

Fermilab scientists have also established and worked closely with several observatories off-site in order to investigate cosmic rays and dark energy. These projects include the **Pierre Auger Observatory** in western Argentina and the **Sloan Digital Sky Survey (SDSS)** at a large telescope in New Mexico. Collaborations that are still in their early stages include the **Dark Energy Survey (DES)** and the **Large Synoptic Survey Telescope (LSST)**, both based out of observatories in the Chilean Andes. For DES, Fermilab collaborated with Argonne National Laboratory to construct and test a 570-megapixel camera, which will begin collecting data before the end of 2011. For LSST, Fermilab is helping to develop an 8.4 meter three-billion pixel digital camera that will survey the entire visible sky, searching for clues about dark matter and dark energy.

III. Employment and Earnings Impact

As discussed in the previous section, Fermilab employs almost 2,000 people directly to engage in high-energy physics. In this section, we discuss the economic benefits of the lab's expenditures for Illinois residents, as well as the benefits that stem from those who visit the lab for conferences, research, and other activities.

ECONOMIC IMPACT DEFINED

Economic impact is the measure of net new economic activity that occurs in a defined geographic region as a result of an investment, event, project, or industry. A direct economic impact stems from the initial spending or investment, while an indirect economic impact stems from the recirculation of dollars within the defined region. Economic impact is measured in terms of 1) total new economic activity, 2) earnings to workers, and 3) number of jobs created or supported.

We specifically estimated the *net new* economic impact of Fermilab. We emphasize *net* and *new* as we were careful to exclude expenditures that would have been realized in the area regardless of Fermilab's operations, and we were careful to consider costs associated with generating an expenditure. For example, the opening of an additional fast food restaurant along a busy commercial corridor will not create significant new economic activity. Instead it will likely just shift activity within the market as consumers spread their spending amongst all of the fast food outlets. However, Fermilab, with its unique types of expenditures and operating revenue from the federal government, does have a significant economic impact. See "Economic Impact Methodology" on page A-5 for a complete description of our methodology.

Impact Areas. In this analysis we specifically assess Fermilab's economic impact on the state of Illinois as a whole, and on just the Chicago region. A map of these areas and the relative location of the lab is shown on page 13. The Chicago region includes the counties of Cook, DeKalb, DuPage, Grundy, McHenry, Will, Kane, and Kendall.

FERMILAB EXPENDITURES

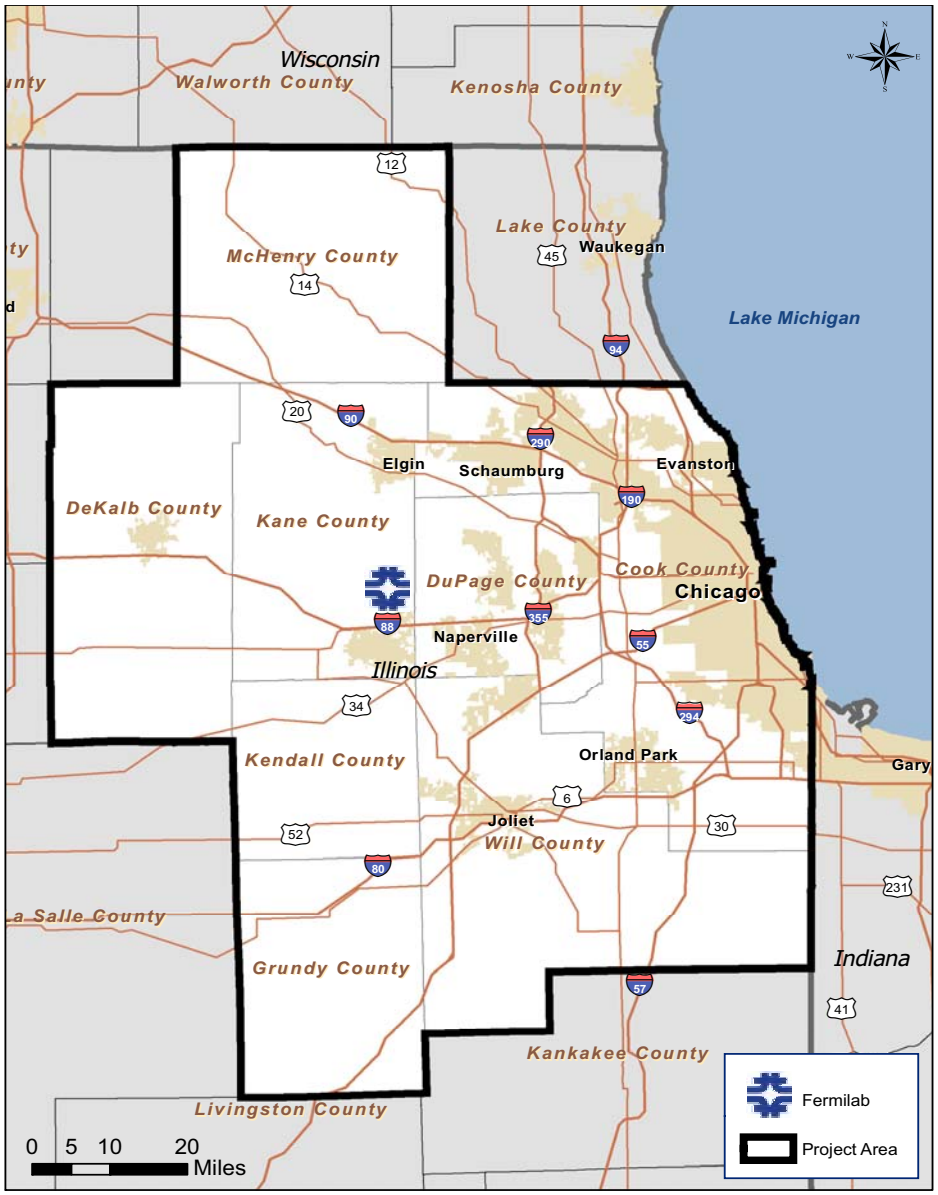
To understand the economic impact that Fermilab has on the Chicago region and the state of Illinois requires first understanding the expenditure patterns of the lab. The lab provided data on each of these areas of expenditure for fiscal year 2010.

Fermilab Expenditures

In fiscal year 2010, Fermilab had total expenditures of $478.3 million. This represents the total cash outflows of the lab during the year, covering operating expenses, capital expenditures, and payroll for employees. Each payment recorded was analyzed based on vendor name, vendor location data, payment

amount and account category. From this we were able to allocate the expenses into categories, and assess whether the payment was directed within the Chicago region, within the state, or to a location outside Illinois.

FIGURE 1. Eight-County Chicago Region



Source: Anderson Economic Group, LLC, 2011; ESRI Inc., 2011, Fermilab, 2011.

Expenditures by Category. Table 2 summarizes the total fiscal year 2010 expenditures made by Fermilab. The expense categories align with the industry sector to which the payment was directed. We determined this based on the payment category (e.g. materials and supplies indicates a wholesale industry trans-

action, while legal services indicates a professional service industry transaction) and the name of the vendor. The "Household" industry sector includes all salary and wages paid to the lab's employees. This was the second largest expense category after professional, scientific, and technical services.

Expenditures by Geographic Area. To assess where the expenditures were directed required the use of our Geographic Information System (GIS). We used the GIS to assess the location data given for each payment entry and to identify whether the payment was made to a vendor within Illinois, the Chicago region, or elsewhere. As shown in Table 2, some 58 percent of Fermilab's total expenditures were made in the Chicago region ($276 million). These expenditures account for 96 percent of the lab's expenditures in Illinois.

TABLE 2. Fermilab Expenditures in FY 2010

Receiving Industry	Total Expenditure	Share of Total in Chicago Region	Expenditure in Chicago Region
General Manufacturing	$5,905,681	98%	$5,810,388
Households	$111,609,762	96%	$107,419,158
Insurance Carriers	$62,375,248	43%	$26,603,847
Other Services	$60,115	27%	$16,454
Prof, Sci, Tech Services	$169,320,896	52%	$87,245,447
Social Assistance	$37,960,656	0%	$-
Travel & Accommodations	$3,622,589	90%	$3,266,724
Utilities[a]	$26,913,798	81%	$21,754,551
Wholesale Trade	$60,504,976	40%	$24,227,495
Grand Total	**$478,273,721**	**58%**	**$276,344,065**

Source: Fermi National Accelerator Laboratory, Finance Department
Analysis: Anderson Economic Group, LLC

a. We assumed 80% of total expenditures was for local utility activity. This accounts for the generation of power and other operations by these companies outside the region.

Fermilab Visitors

Researchers, business people, students, and many others visit Fermilab each year. Many of these visitors come from outside the region and the state, and with each visit they bring new expenditures to the area. Many of these visitors will stay overnight in the area, either for a few nights to attend a conference or special event, or for longer durations while they are working on long-term research assignments at the lab. Below we present our analysis of estimated expenditures associated with these visitors. We do so by estimating the total expenditures on things like transportation, accommodations, and meals that overnight visitors bring to the region.

Visiting Users' Expenditures. Fermilab, in addition to its permanent workforce, also hosts many visiting researchers who are performing long-term research projects at the lab, and who take up temporary residence in the area while com-

pleting their research. These visiting users come from across the country, and around the world, and provide a notable expenditure base while they are in the region. During fiscal year 2010 there was an average of 1,000 users at Fermilab from institutions outside of the State of Illinois. The visiting users combined for a total of 360,000 visitor days within the region. With an assumed average daily expenditure of $100 for temporary housing, transportation, meals, incidentals, and other items while living in the area, these visitors resulted in nearly $36 million in annual expenditures within Illinois and the Chicago region.[5]

Event and Conference Visitor Expenditures. In fiscal year 2010 Fermilab hosted a number of conferences, such as a one-day "New Perspectives 2010" conference with 30 attendees and an 11-day "Hadron Collider Physics" summer conference with 148 attendees. In total these and other conferences were attended by more than 2,000 participants, some three-quarters of which were people not usually at the lab. Over the duration of the year this resulted in a total of 5,428.5 visitor days.

While attending conferences these visitors stay in the region and incur expenses related to accommodations, meals, and incidental expenditures. Federal *per diem* expense guidelines suggest an average daily expenditure of $161 per person for these categories. This totals to $873,989 for FY 2010.[6]

Geographic Distribution of Visitor Expenditures. Of the total $36.9 million in visitor related expenditures, we conservatively estimate that nearly $33.2 million of these expenditures stay in the region, and $35.0 million stays in the state, with the remainder directed out of state, mainly in fees passed along to the out-of-state headquarters that oversee many of the national hotel and food chain operators.

FERMILAB REVENUE SOURCES

When analyzing economic impacts, we only count expenditures as being new to an area, on net, if the funds that supported the expenditure would not have been spent in that area in the absence of the event or institution being studied. In other words, the regional economic impact of Fermilab is restricted to funding that supports its expenditures that would not have gone to another purpose in the region if the lab were not in operation.

Fermi National Accelerator Laboratory received $459 million in total funding in FY 2010 (October 1, 2009 to September 30, 2010). The overwhelming majority of these funds (94%) were from the federal government. The Department of Energy is the primary source of funds, but Fermilab also performs research for other federal departments. Of the money that went to Fermilab directly from

5. Visiting user data provided by Fermilab for FY 2010. Our assumption of 360,000 visitor days in FY 2010 is based on data that showed that the average stay for users is 501 days and interviews with Fermilab staff that said 1,000 users were on-site the entire year.
6. Conference attendee data provided by Fermilab conference office for FY 2010.

federal agencies or departments, $19.1 million was allocated due to the American Recovery and Reinvestment Act (ARRA, also known as the federal stimulus package). The breakdown of funding provided to the Lab in fiscal year 2010 is shown in Table 3 below.

TABLE 3. Fermi National Accelerator Laboratory Revenues, FY 2010

Source of Revenue	Amount (millions of $)	% of Total Revenue
Federal Government (not ARRA)	$419.5	*91.4%*
Federal Government (ARRA)	$19.1	*4.2%*
State, Universities, Businesses, and Non-profits	$20.4	*4.4%*
TOTAL REVENUE	**$459.0**	

Source: Fermi National Accelerator Laboratory
Analysis: Anderson Economic Group, LLC

Given the very specialized nature of operations at the lab, it is very unlikely that any of the funds provided to the lab would have come to the region if the lab were closed, or located elsewhere. As such, we have assumed that 100% of Fermilab's expenditures are net new to the region and the state.

ECONOMIC IMPACT FROM FERMILAB EXPENDITURES

Economic Impact Multipliers

As each dollar spent by Fermilab enters the state and regional economy it supports additional business activity, jobs, and payroll. The magnitude of this additional activity varies by industry and region, and these variances are reflected in the economic impact multipliers used in our analysis.[7] Larger multipliers indicate that spending by an industry in a region is likely to produce greater levels of indirect economic impacts as the dollars continue to circulate in the area. Lower multiples suggest that the spending is likely to produce smaller levels in indirect economic impacts. Spending that supports significant reinvestment in an area produces a high multiplier, while spending that quickly leaves the region and is reinvested elsewhere yields a low multiplier.

Please see table Table A-1, "State of Illinois Economic Impact Multipliers," on page A-2 and Table A-3, "Chicago Region Economic Impact Multipliers," on page A-3 for the economic impact multipliers used in this analysis.

Fermilab Economic Impacts in State of Illinois

Based on our analysis of FY 2010 expenditures by Fermilab and visitor spending, we estimate that the lab generated $643.0 million in total output in the state of Illinois with $196.6 million in new earnings for households. We also estimate

7. Economic multipliers used in this analysis are from the United States Bureau of Economic Analysis (BEA), Regional Input-Output Modeling System (RIMS).

the lab created over 4,500 jobs in the state. This economic impact comes from the lab's direct expenditures and visitor expenditures. These are shown separately below.

Fermilab Expenditures. Fermilab had total expenditures of $288 million directed to vendors and employees within the state of Illinois during fiscal year 2010. These expenditures were classified into nine different industry groups, including households, and economic multipliers were applied to estimate an economic impact. With the multiplier affects, the $288 million of expenditures generated total economic output of $564.6 million dollars. In doing so it also created 3,899 jobs and earnings of $174.6 million for Illinois residents, as shown in Table 4 below. This analysis is presented in more detail in Table A-2.

Fermilab Visitor Expenditure Impacts. Spending by Fermilab visitors contributed to $78.5 million in economic output in the state of Illinois in FY 2010. We estimate that 630 jobs were created due to spending by Fermilab visitors. See Table 5 below and Table A-5, "Fermilab Visitor Expenditures and Economic Impacts (FY 2010)," on page A-4.

TABLE 4. Fermilab Economic Impacts in Illinois

	Economic Output	Earnings	Employment
Visitor Economic Impacts	$78,467,848	$22,069,082	630
Fermilab Expenditure Economic Impacts	$564,572,694	$174,550,482	3,899
Total Economic Impacts	**$643,040,542**	**$196,619,564**	**4,529**

Source: Anderson Economic Group, LLC

Fermilab Economic Impacts in the Chicago Region

Fermilab's expenditures are estimated to have contributed to the creation of $584.3 million of total economic output in the Chicago region while creating almost 4,000 jobs and $173.1 million in earnings for households. The impacts due to the lab's direct expenditures and visitor expenditures are described separately below.

Fermilab Expenditure Impacts. The nearly $276 million of Fermilab expenditures directed to vendors and employees in the Chicago region were also assigned to nine different industry groups, including households. As these groups received and reinvested the funds they contributed to an estimated economic output of $512.3 million dollars, 3,392 jobs, and $153.2 million in earnings for residents in the Chicago area. This analysis is presented in more detail in Table A-4, "Economic Impacts by Fermilab Expenditures in Chicago Region," on page A-3.

Fermilab Visitor Expenditure Impacts. Spending by Fermilab users and visitors in the Chicago region resulted in over $72 million in economic output and

570 jobs. For more detail, see Table A-5, “Fermilab Visitor Expenditures and Economic Impacts (FY 2010),” on page A-4.

TABLE 5. Fermilab Economic Impacts in Chicago Region

	Economic Output	Earnings	Employment
Visitor Economic Impacts	$72,014,900	$19,911,954	570
Fermilab Expenditure Economic Impacts	$512,297,339	$153,230,348	3,392
Total Economic Impacts	**$584,312,239**	**$173,142,302**	**3,962**

Source: Anderson Economic Group, LLC

IV. Fermilab's Broader Contributions to American Science

American science and engineering play an important role in the country's economic development. Previous sections described the important basic science infrastructure Fermilab supports and the important current research Fermilab is undertaking. This section describes the additional contributions that Fermilab makes by producing technology with spin-off benefits, collaborating with outside researchers and private companies, and contributing to the training and education of future scientists.

FERMILAB TECHNOLOGY WITH WIDER BENEFITS

While Fermilab's mission is centered on basic science, the cutting-edge nature of the research performed there has required the development of new equipment and techniques, some of which have been used extensively by others. In essence, the main source of direct development of new technologies associated with Fermilab comes as a side-effect of their scientific mission. To push the boundaries of science Fermilab has had to create machines, techniques, and organizations that have never been built before. This section provides several examples of Fermilab creating or working with industry to create new technologies in collaboration with other science institutions and private industry.

One straightforward way that Fermilab and other particle accelerators have created technology that is used in the private economy is the widespread use of particle accelerators for many industrial applications. There are over 30,000 particle accelerators in use around the world, the majority of which are not being used for basic science research.[8] Instead they are being used for industrial processing of materials such as heat-shrinkable plastics, auto tires, the manufacture of computer chips. They are also used in security applications such as scanning shipping containers for certain materials. The continued use and advancement of accelerator technology by Fermilab and others have allowed the private accelerator industry to produce products they could otherwise not have produced, and at a lower cost.

In the early 1970's Fermilab needed superconducting wire to build the first superconducting synchrotron. While the type of wire they needed was available commercially at the time, the scale of Fermilab's need was unprecedented: they needed 140 thousand miles of superconducting niobium-titanium wire. This large demand from a stable source, along with patient management by Fermilab to help working relationships evolve among material suppliers, researchers, and manufacturers, allowed the superconducting wire industry to expand. The industry achieved the level of expertise and scale it needed to continue produc-

8. U.S. Department of Energy, *Accelerators for America's Future*, available at http://www.acceleratorsamerica.org/index.html.

ing the product at much lower cost after it had filled Fermilab's need, which allowed other industries, such as the medical equipment industry that manufactures MRI machines, to flourish.

More recently, Fermilab's demand for a low-cost, high-quality scintillator (a specialized instrument that detects certain types of radiation produced in neutrino interactions with other materials) led to the development of a new extrusion manufacturing technique to meet Fermilab's needs. Created in a collaboration between Fermilab and the Northern Illinois Center for Accelerator and Detector Development at Northern Illinois University, the new process will allow high-quality, low-cost scintillators to be produced for advanced physics research worldwide.

As discussed in "Contributions to Basic Science Research" on page 8, Fermilab runs a key computing facility that gives U.S. scientists access to experiments at the LHC. Fermilab's experience with creating and operating large particle accelerators gave it the combination of project management and science experience to contribute to the completion of the Large Hadron Collider.

One important current example of technology development at Fermilab is its work on superconducting radio frequency (SRF) cavity design and manufacturing. This technology is crucial for next generation improvements in particle accelerator performance, including the completion of Project X. Once development is completed, this technology will be available to other institutions wishing to build the next generation of particle accelerators.

FERMILAB COLLABORATIONS

As discussed in "Overview of Fermilab's Operations and Basic Science Research" on page 5, Fermilab has been host to cutting edge particle accelerators since its inception. While the Tevatron's operations will end in September 2011, Fermilab's facilities are currently used by many researchers from other institutions and in conjunction with private businesses, as we describe below.

Users of Fermilab Facilities

Visiting scientists at Fermilab improve Fermilab scientists' connections with the American and international scientific communities and bring the world's brightest scientists to bear on the important questions being investigated at Fermilab facilities. They also have their own economic impact on the local community surrounding Fermilab as they spend time in the region and enrich the local community with their outside perspectives and experiences.

In FY 2010, Fermilab had 2,300 users with most of the users on-site. These visitors come from institutions in 42 countries (including the U.S.) in North America, South America, Europe, and Asia to work on collaborations such as the CMS experiment and the Dark Energy Survey.

Illinois Accelerator Research Center

One important new facility planned for Fermilab is the Illinois Accelerator Research Center (IARC) being developed with the Illinois Department of Commerce and Economic Opportunity and the U.S. Department of Energy. Construction is set to begin in late 2011 and is scheduled to be completed in approximately two years. The facility will be over 80,000 square feet, including 42,000 square feet of new space added to a refurbished building. It will provide offices and specialized technical space for Fermilab and Argonne National Laboratory scientists and engineers, local university researchers, and private companies to pursue accelerator development. All 86 institutions that are part of the Universities Research Association will have access to the facility, including the University of Chicago, the University of Illinois, the Illinois Institute of Technology, Northern Illinois University, and Northwestern University.

In addition, it is expected that university and industrial personnel will form partnerships that use office and technical space in IARC to develop new and improved accelerator technology. IARC will help the partners in this facility accomplish several goals. First, it will facilitate advancements in accelerator science and technology by bringing top researchers from different institutions together. These advancements may lead to new large accelerator projects nationwide, including at Fermilab and Argonne laboratories. Second, partnerships with universities will facilitate the education and training of the next generation of scientists, engineers, and technical staff needed to maintain and improve the rapidly growing numbers of accelerators used in scientific research and applications in the private economy. IARC will also provide opportunities for partnerships between scientists and private companies to co-develop and transfer useful technologies to private companies. These accelerator-based products will be used to improve existing industries and spawn new ones.

Collaborations with Private Companies

Fermilab has also worked with several private companies to develop specific components for their work:

- Advanced Energy Systems is a New York company that develops and sells accelerator-technology products with applications in the scientific community, medicine, defense, and homeland security. The firm has worked with Fermilab on the development of the lab's superconducting radio frequency accelerator technology (discussed earlier in "Project X" on page 9) that will be used in the next generation of accelerators. Technology transfer has flowed in both directions in this relationship, most recently with a contract to transfer a Fermilab-developed electropolishing technique for the manufacture of superconducting RF structures.
- Fermilab worked with Pavac Industries, Inc., a Canadian electron beam technology firm, to develop products suitable for use in particle accelerators. Applications of electron beam technology provided by Pavac include welding, machining, drilling, coating, and treatment of flue gasses to remove sulfur.

- Euclid TechLabs LLC, a research and development company in Ohio and Maryland, specializes in the development of dielectric materials for particle accelerators, communications, and microwave applications. Fermilab has worked with Euclid to develop their technology for use in particle accelerators at Fermilab.
- Fermilab has a partnership with Indiana-based Roark Industries Incorporated and Michigan-based Niowave Inc. to develop new superconducting structures for the next generation of proton and electron linear accelerators.
- Tezzaron Semiconductor has worked with Fermilab to develop and produce 3-dimensional integrated circuits. This important technology helps computer memory and microprocessors transfer data back and forth at very high volumes within practical constraints on physical distance and power usage. Work with a Fermilab-organized consortium of national and international laboratories has helped the Illinois- and Singapore-based company make significant progress in developing its design and manufacturing processes. Particularly helpful has been the consortium's agreement to purchase the new integrated circuits produced by Tezzaron. This work has brought the company several steps closer to producing commercial 3-D integrated circuits, which will have applications in all industries that push the boundaries of supercomputing.
- Illinois-based Vega Wave Systems specializes in laser chips, fiber amplifiers, and other optoelectronic components used in fiber optics. The firm has partnered with Fermilab to push the boundaries of data processing at higher speeds with smaller electronics using 3-dimensional integrated circuits. One recent project includes integrating a laser transmitter into an advanced 3-dimensional chip, allowing faster and higher-volume data flow over a given distance compared to existing methods such as copper wires. The resulting chips will allow Fermilab to place more sensors in a given space, which is a crucial component of improving the performance of the particle detectors that help scientists observe high-energy physics experiments. As mentioned above when discussing Tezzaron Semiconductor's work with Fermilab, 3-D integrated circuit technology could play a part in the ongoing march for speed and miniaturization for which the microprocessor industry is famous.
- American Semiconductor is an Idaho-based firm specializing in semiconductors with applications in aerospace, military, and other private applications. They have partnered with Fermilab on research and development in "radiation-hard" electronics that are much more tolerant of x-ray, particle, and other radiation than standard electronics. High levels of radiation pose major challenges for applications in particle accelerators, whose purpose is to produce such radiation. When developed, this technology could have many private sector applications, including in commercial and medical x-ray detectors and homeland security applications such as scanning shipping containers.

FERMILAB'S CONTRIBUTION TO THE SCIENCE PIPELINE

Fermilab also contributes to the long-term health of American science by providing information, inspiration, practical experience, and direct research opportunities for K-12 students, college students, and graduate students.

Fermilab outreach to K-12 students includes field trips to Fermilab for students in the entire age range, including tours and engagement with the physics at Fer-

milab for high school students. Over 7,000 elementary and middle school students visit the restored prairie on Fermilab's grounds (including on the ground above the main accelerator ring) to learn about the ecology of the region before modern development. Over 300 local high school students each year participate in a Saturday Morning Physics course hosted by Fermilab. In all, about 18,000 students participated in activities at Fermilab in 2008 and 2009, with another 12,000 students visited in classrooms by Fermilab staff.

Fermilab also engages with science teachers through professional development activities, research internships for high school science teachers, and teacher resource materials to help science teachers develop their curricula. In all, about 2,000 teachers per year participate in teacher training activities associated with Fermilab.

College students also find many opportunities to learn at Fermilab. There are approximately 90 internships for U.S. and international college students each year through 11 different programs run by Fermilab. These internships allow college students to have direct participation in the actual science being performed at Fermilab.

The most direct way that Fermilab contributes to the pipeline of scientists in America is its engagement with graduate education. Having specialized, cutting-edge experimental equipment allows Fermilab to make a material contribution to the number of top scientists produced by the country each year. Over 500 graduate students and dozens of post-doctoral researchers work on research at Fermilab. In 2008, 92 PhDs were awarded for research performed at Fermilab. In total, over 1,600 PhDs have been awarded to Fermilab researchers since 1972.

Fermilab and its staff also engage with the public in many other ways. Fermilab runs the "Ask A Scientist" program that allows people in the area to meet with Fermilab scientists and engineers monthly. Fermilab websites, which include over 250 online projects, received over 9 million hits in 2009.

Appendix A. Data and Methodology

This appendix includes methodological discussions, as well as data tables.

ECONOMIC IMPACT ANALYSIS TABLES

This appendix includes the following tables:

TABLE A-1. State of Illinois Economic Impact Multipliers

	Economic Output	Earnings	Employment
Accommodations and Transportation*	2.24	0.63	17.98
Households	1.51	0.42	11.40
Insurance Carriers	2.43	0.71	14.29
Other Services	2.41	0.71	21.01
Professional, Science, Tech Services	2.30	0.83	16.55
Social Assistance	2.37	0.76	34.74
Utilities	1.80	0.43	7.50
Wholesale Trade	2.09	0.63	12.73
Misc. Manufacturing	2.39	0.55	11.40

Source: United States Bureau of Economic Analysis, Regional Input-Output Modeling System (RIMS II).

* The Accommodations and Transportation multipliers reflect an average of two separate industry multipliers. This was done to reflect that travel expenditures are primarily directed to these two separate industries.

Note: Output and Earnings multipliers represent the total dollar change in output or earnings that occurs across all industries for each additional dollar delivered to final demand in the listed industry. Employment multiplier represents the total change in jobs that occurs in all industries for each additional $1 million dollars delivered to final demand in the listed industry.

TABLE A-2. Economic Impacts by Fermilab Expenditures in State of Illinois*

	Economic Output	Earnings	Employment
Accommodations and Transportation	$7,328,139	$2,059,406	59
Households	$164,839,887	$45,513,295	1,242
Insurance Carriers	$65,065,940	$18,989,259	382
Other Services	$39,583	$11,656	0
Professional, Science, Tech Services	$211,613,920	$76,410,269	1,520
Social Assistance	$10,054,940	$3,228,261	147
Utilities	$39,208,228	$9,280,492	163
Wholesale Trade	$52,521,285	$15,875,496	319
Misc. Manufacturing	$13,900,772	$3,182,349	66
Total Economic Impact	$564,572,694	$162,564,394	3,678

Source: Anderson Economic Group, LLC.

* Includes Chicago Region

Note: Each industry line represents the economic impact that is created across all industries by the total Fermilab expenditures directed to the named industry. Sums may not equal totals due to rounding.

TABLE A-3. Chicago Region Economic Impact Multipliers

	Economic Output	Earnings	Employment
Accommodations and Transportation*	2.17	0.60	17.18
Households	1.42	0.38	10.66
Insurance Carriers	2.35	0.65	13.12
Other Services	2.34	0.67	20.00
Professional, Science, Tech Services	2.22	0.78	15.54
Utilities	1.64	0.36	6.29
Wholesale Trade	2.02	0.59	11.84
Misc. Manufacturing	2.11	0.50	10.76

Source: United States Bureau of Economic Analysis, Regional Input-Output Modeling System (RIMS II).

* The Accommodations and Transportation multipliers reflect an average of two separate industry multipliers. This was done to reflect that travel expenditures are primarily directed to these two separate industries.

Note: Output and Earnings multipliers represent the total dollar change in output or earnings that occurs across all industries for each additional dollar delivered to final demand in the listed industry. Employment multiplier represents the total change in jobs that occurs in all industries for each additional $1 million dollars delivered to final demand in the listed industry.

TABLE A-4. Economic Impacts by Fermilab Expenditures in Chicago Region

	Economic Output	Earnings	Employment
Accommodations and Transportation	$7,103,654	$1,946,641	56
Households	$152,395,560	$41,130,796	1,145
Insurance Carriers	$62,423,268	$17,249,935	349
Other Services	$38,440	$10,972	0
Prof, Sci, Tech Services	$193,588,922	$67,929,305	1,356
Utilities	$35,573,043	$7,820,761	137
Wholesale Trade	$48,910,467	$14,223,962	287
Misc. Manufacturing	$12,263,986	$2,917,977	63
Total Economic Impact	$512,297,339	$153,230,348	3,392

Source: Anderson Economic Group, LLC.

Note: Each industry line represents the economic impact that is created across all industries by the total Fermilab expenditures directed to the named industry. Sums may not equal totals due to rounding.

TABLE A-5. Fermilab Visitor Expenditures and Economic Impacts (FY 2010)

	Total Expenditure	Amount Assumed In-State	Amount Assumed Regional
Over-Night Visitors			
Visiting Users from Non-Illinois Institutions	$ 36,000,000	$ 34,200,000	$ 32,400,000
Visiting Conference and Event Attendees	$ 873,989	$ 830,289	$ 786,590
Total Expenditures	$ 36,873,989	$ 35,030,289	$ 33,186,590

Source: Anderson Economic Group, LLC.

Economic Impacts from Other Fermilab Related Expenditures in Chicago Region

	Economic Output	Earnings	Employment
Over-Night Visitors			
Visiting Users from Non-Illinois Institutions	$ 70,308,000.00	$ 19,440,000	557
Visiting Conference and Event Attendees	$ 1,706,899.54	$ 471,953.79	14
Total Impact	$ 72,014,900	$ 19,911,954	$ 570

Source: Anderson Economic Group, LLC.

Economic Impacts from Other Fermilab Related Expenditures in State of Illinois

	Economic Output	Earnings	Employment
Over-Night Visitors			
Visiting Users from Non-Illinois Institutions	$ 76,608,000.00	$ 21,546,000.00	615
Visiting Conference and Event Attendees	$ 1,859,847.53	$ 523,082.12	15
Total Impact	$ 78,467,848	$ 22,069,082	$ 630

Source: Anderson Economic Group, LLC.

ECONOMIC IMPACT METHODOLOGY

In order to estimate the economic impact of Fermilab we used an economic model that translates an increase in demand (e.g. spending) into total economic impact, which can be expressed in output, earnings and employment. The specific model we used is the U.S. Department of Commerce Regional Input-Output Modeling System (RIMS II), which uses multipliers to estimate final demand. We identify our assumptions for inputs, substitution effects, and multipliers in the preceding tables. This avoids the common problems of "black box" models for which some of the methodology and assumptions are hidden.

ESTIMATING EMPLOYMENT, OUTPUT AND EARNINGS

We estimated the net economic impact of Fermilab in the State of Illinois and in the eight-county Chicago-Naperville-Joliet Metropolitan Division, which we call the "Chicago Region" in our analysis. We define net economic impact as the difference in employment, output, and earnings in two scenarios: (1) the current scenario, where Fermilab operates in the Chicago Region, and (2) a counter factual scenario, in which we assume the lab was not in the area. We used the following methodology when estimating net economic impact.

1. Identified the impact region for the analysis.
   The first step in estimating the economic impact of a new project is to select the region for the analysis where additional earnings and employment occurs. In this analysis we looked at two regions: The State of Illinois and the Chicago Region of Illinois (Cook, DeKalb, DuPage, Grundy, McHenry, Will, Kane, and Kendall Counties).
2. Assessed the expenditure base.
   Next we assessed the expenditures that occurred in the impact regions in FY 2010 as a result of the lab being in operation. Payroll, operating, and capital expenditure data was obtained from the lab, and analyzed to measure where the expenditures were being directed. This was done using vendor and employee address data (city, state, and zip code information).[1] We also used information on visitors to and long-term users of the laboratory to estimate spending by out-of-region visitors who make expenditures while in the market.
3. Determined substitution.
   We determined substitution for the lab using revenue source information and professional judgement based on the availability of the labs functions elsewhere in the market. Revenue data showed that more than 95 percent of all of the labs revenue came from out-of-state sources, and that the majority of in-state revenue came from the University of Chicago, which administers the lab and forwards on revenues from federal sources. This, along with the fact that there is no ready substitute in the state, and in many cases the country, for Fermilab's services, led us to assume that none of the expenditures would be substituted for if the lab were not in the region.

1. For utility payments, which we found were being mailed to offices in distant states, we assumed that 80 percent of the total expenditure was actually for local utility activity, with the remaining 20 percent non-local and non-state.

4. Considered alternative uses of the land.
   Fermilab is situated in Batavia, Illinois, some 40 miles west of Downtown Chicago. We considered what the area would be like if the lab had not been started in its current location. We believe the area would be mostly residential, with some parks and light commercial areas. We do not believe the alternative uses would have contributed to new employment or increased demand for goods and services in the region. Most of the development that would have taken place has already occurred around the lab.

5. Estimated economic impact.
   To estimate Fermilab's impact (in terms of total earnings, employment and output), we multiplied the net new demand (expenditures) by RIMS multipliers. These multipliers are industry specific, estimated by the U.S. Department of Commerce, and are customized to the region. We then chose the RIMS industry category that most closely corresponded to the industries that the expenditures were being directed to. See Table A-1, "State of Illinois Economic Impact Multipliers" on page A-2 and Table A-3, "Chicago Region Economic Impact Multipliers" on page A-3.

Appendix B. About the Authors

Anderson Economic Group, LLC is a research and consulting firm specializing in economics, finance and business valuation, and market and industry analysis. The firm has offices in Chicago, Illinois and East Lansing, Michigan. AEG has conducted economic and fiscal impact studies for universities across the United States. For more information please visit www.AndersonEconomicGroup.com.

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Ms. Sallee is a Senior Consultant and Director of the Public Policy, Fiscal, and Economic Analysis practice area.

Ms. Sallee's recent work includes preparing the report *Dollars and Sense*, a 2011 citizen's guide to Michigan's financial health released by Governor Rick Snyder. Ms. Sallee also completes an annual economic impact assessment for Michigan's University Research Corridor (Michigan State University, University of Michigan, and Wayne State University), and has done work for a number of other universities including the University of Chicago. She is also the lead author of the firm's annual 50-state business tax burden study.

Prior to joining Anderson Economic Group, Ms. Sallee worked for the U.S. Government Accountability Office (GAO) as a member of the Education, Workforce and Income Security team. She has also worked as a market analyst for Hábitus, a market research firm in Quito, Ecuador and as a legislative assistant for two U.S. Representatives.

Ms. Sallee holds a Master of Public Policy degree from the Gerald R. Ford School of Public Policy at the University of Michigan and a Bachelor of Arts degree in economics and history from Augustana College.

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Mr. Watkins is a Senior Consultant with Anderson Economic Group, LLC, with expertise in economic, industry, and market analyses, as well as public policy. He manages the firm's market and industry analysis practice area, working with public and private sector clients to deepen understandings of their market and place in the economy, and to develop strategies to strengthen their positions.

Among the clients for whom he has worked are more than 85 automobile dealerships; the Project Management Institute; City of Hamtramck, Michigan; City of Lansing, Michigan; Oakland County, Michigan; Collier County, Florida; Northern Michigan University; Michigan State University; Ferris State University; Michigan Retailers Association; and the West Virginia High Technology Consortium Foundation. Recent publications by Mr. Watkins include: "Land Use and Infrastructure Investments by Olympic Host Cities: Legacy Projects for Long-term Economic Benefits," and The State Economic Handbook, as published by Palgrave Macmillan in 2008, 2009, and 2010. Mr. Watkins has made

presentations to a number of audiences and media outlets on topics concerning the automotive industry, economics, education finance, and industry trends. He has also provided expert testimony in legislative and legal hearings, including automobile dealership arbitrations.

Prior to joining Anderson Economic Group in 2001, Mr. Watkins was an analyst in the automotive market and planning group at J.D. Power and Associates, and a marketing assistant with Foster, Swift, Collins, and Smith P.C.

Mr. Watkins holds an M.B.A. from the Eli Broad College of Business at Michigan State University. He also has a B.A. in marketing from Eli Broad College of Business and a B.A. in international relations from the James Madison College, both at Michigan State University.

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Mr. Rosaen is a Consultant at Anderson Economic Group, working in the Public Policy, Fiscal, and Economic Analysis practice areas. Mr. Rosaen's background is in applied economics and public finance.

Mr. Rosaen's recent work includes several economic and fiscal impact analyses, including of proposed real estate developments, power plants, and infrastructure projects; analysis of tax incentives; an analysis of the impact of federal tax incentives on the freight rail industry; and an analysis of the economic contribution that research universities make in the State of Michigan.

Prior to joining Anderson Economic Group, Mr. Rosaen worked for the Office of Retirement Services (part of the Michigan Department of Management and Budget) for the Benefit Plan Design group. He has also worked as a mechanical engineer for Williams International in Walled Lake, Michigan.

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Recent projects he has worked on include an analysis and comparison of public and privately funded capital projects across the United States, an economic impact analysis of member businesses for a leading trade organization, as well as analyses of the fiscal condition and tax policies of Michigan's state and local governments.

Prior to joining AEG, Mr. Horwitz acted as the Coordinator of Distribution for the Community Center of St. Bernard near New Orleans, where he oversaw the distribution of donated food, clothes, and household supplies to low-income residents of St. Bernard Parish and New Orleans' Lower Ninth Ward.

Mr. Horwitz graduated with Honors from Swarthmore College with a Bachelor of Arts in Physics and Philosophy. He earned his Master of Public Policy degree from the Harris School of Public Policy Studies at the University of Chicago in 2011.