US Muon Collider Community submission to the European Strategy for Particle Physics Update

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Signatures of US supporters to be collected

Executive Summary

This document is being submitted to the European Strategy for Particle Physics Update (ESPPU) process on behalf of the US Muon Collider community, with its preparation coordinated by the interim US Muon Collider Coordination Group. The purpose is to inform ESPPU about the US plans for Muon Collider R&D, explain how these efforts align with broader international R&D initiatives, and present the US community vision for the future realization of this collider.

The Large Hadron Collider (LHC) has had a transformative impact on high-energy physics, most notably with the discovery of the Higgs boson. This discovery without any sign for other new physics has spurred critical inquiries into the origins of electroweak symmetry and the underlying structure of the universe. In response, the P5 report underscores the need for sustained research and development (R&D) efforts to design a future 10 TeV parton center of mass energy collider, which could unlock the answers to the questions the LHC has helped pose. Among the various possible collider technologies, a muon collider stands out as the most powerful tool for addressing many of the key questions raised by the LHC. Furthermore, a muon accelerator facility enables unique opportunities to probe a broad array of other scientific challenges, including dark sectors via beam dumps, short and long baseline neutrino programs, charged lepton flavor violation, and more. To fully leverage these opportunities, the U.S. scientific community intends to build on the P5 report's recommendations by rigorously exploring the feasibility of this cutting-edge technology and its scientific potential to help realize our "muon shot".

Since the latest Snowmass process, the U.S. Muon Collider community has been working closely with international partners under the coordination of the International Muon Collider Collaboration (IMCC). Together, we have developed a detailed R&D program aimed at addressing the key technological risks associated with muon colliders. This program outlines the necessary resources and timeline for its execution. Significant technical progress has been made in Europe in the last few years, with IMCC already contributing roughly 50% of the required resources to stay on this timeline. The US Muon Collider community aspires to contribute at least the remaining 50%, focused on the areas of US strengths and interests. A central component of the R&D roadmap is an ionization cooling demonstrator, which is essential for establishing that the luminosity goals of a muon collider are achievable. The demonstrator is expected to be constructed and operational in the 2030s on this timeline, and we hope to host this facility at Fermilab. Assuming expanded funding and successful technological developments, we anticipate achieving technical design readiness for the collider within approximately 20 years, which could pave the way for the start of a construction project in the mid-2040s and operations commencing soon thereafter.

It is clear that no future collider can be built without global support. If the European Strategy for Particle Physics Update (ESPPU) continues to pursue a low-energy e+e- Higgs factory at CERN, its success will require enthusiastic participation from the U.S. community. Similarly, a successful muon collider (wherever it is hosted) will depend on commitments from around the globe, including continued engagement from Europe and expanded engagement from the U.S. We support a U.S. program that allows both of these programs to co-exist, as envisioned by the P5 report.

A potential outcome of this global program is a U.S.-hosted muon collider, built after DUNE Phase-2 construction is completed. This machine would enable physics exploration complementary to the Higgs Factory as well as the most efficient path to exploring nature at the highest energies. This vision is supported by the 2023 P5 report, which calls for hosting a major international collider facility in the U.S., positioning the country as a leader in the global exploration of fundamental physics. Regardless of the ultimate location, we hope that the U.S. and Europe can benefit from close collaboration and mutual support, building on the lessons learned from their partnership in the LHC and neutrino programs.

The U.S. community is engaged and eager to ramp up work on muon colliders. The need for global muon collider R&D efforts is clear, and the community is infused with excitement, both in terms of tackling the technical challenges and the potential for domestic siting. In August 2024, the community had its first open meeting at Fermilab, which had over 300 attendees, 260 of which were in person. Many were newcomers to the effort, looking for the best place to contribute, and over 60 people attended tutorials in detector and accelerator simulation software. The meeting also launched discussion of the formation of the US Muon Collider Collaboration (USMCC), which is in the process of finalizing a constitution.

The creation of the USMCC provides a US organization to engage with the IMCC in delivering the R&D and design work required for the design of a muon collider. In the US context, its formation is a pivotal next step in advancing the P5 recommendations for a muon collider. This collaboration will define the key tasks for the mid-term P5 review, ensuring alignment with strategic goals. It will also be vital to maintain strong engagement with the international community, promoting collaboration and sharing knowledge as we move forward with muon collider research. One critical element of this effort will be the development of a U.S.-based cooling demonstrator proposal, which will be presented to the international community for decisions on its eventual location. Additionally, a comprehensive long-term vision for Fermilab will be developed, positioning it as a central hub for muon collider R&D. This effort will be underpinned by a robust theoretical physics case, which will drive the scientific objectives and discoveries that propel this groundbreaking initiative.

Our community looks forward to continued collaboration with IMCC and strongly believes that it is essential for muon collider efforts in Europe to receive sufficient funding and support. The addendum to the DOE-CERN collaborative agreement, which is currently under development, could facilitate such an arrangement, helping to lay the groundwork for international cooperation on this transformative project.

Introduction

The Higgs boson is central to many of the most important outstanding questions in particle physics. While we know the Higgs plays a role in the origin of mass, we do not yet know the nature of electroweak symmetry breaking and what sets its scale. Precision measurements of the Higgs potential are crucial to address these questions, which will shed light on the origin and fate of the universe. The nature of the Higgs boson itself – whether it is an elementary or a composite particle, or whether a new symmetry prevents its mass from being pulled up to the Planck scale – requires study at a higher energy collider. The Higgs and the electroweak scale may also play a key role in understanding phenomena unexplained by the Standard Model, in particular the nature of dark matter and baryogenesis. Addressing these questions requires collisions at the 10 TeV scale.

Muon colliders offer an attractive path towards the 10 TeV scale, with several unique advantages over hadron and electron machines. Unlike protons, muons are elementary particles and all of the beam energy is available to the collision. At high energies, muons enable vector boson fusion, offering an attractive opportunity to study electroweak symmetry breaking without large QCD backgrounds. Roughly 200 times heavier than the electron, muons also emit around 10^9 times less synchrotron radiation than an electron beam of the same energy, enabling compact and power efficient machines. For example, a ~10 TeV Muon collider complex can be accommodated on the Fermilab site and would be the efficient machine in terms of power per luminosity. Finally, a muon collider program offers unique synergies with the neutrino and precision frontiers, via neutrino factories and fixed target experiments, bridging communities and bringing them together.

This unparalleled potential has reignited significant physics interest in muon colliders over the past several years, and has driven the collider physics community in Europe and in the United States to resume design studies and R&D. Building and operating a muon collider poses several unique technology challenges. Muons must be produced, cooled, accelerated, and brought to collide in sufficient numbers before they decay. Radiation due to the strong flux of collimated neutrinos originating from muon decays in the straight sections of the collider ring need to be managed and mitigated. Experimental detectors have to be designed to handle the diffuse high multiplicity beam-induced background from the muon decays as well. Occupancies in the detectors are expected to be similar to that at HL-LHC; the event rates would be much smaller. Advances over the past decade have brought the necessary technology closer to realization, but targeted R&D is necessary to address engineering challenges, construct demonstrators, and make further design progress**.** Such an R&D program is highly attractive because it would prioritize investment into accelerator and detector development over the cost of large civil construction, maximizing potential societal and scientific benefit.

The possibility of hosting a muon collider in the U.S. has been fully embraced by the US Particle Physics Project Prioritization Panel (P5), evident from the 2023 P5 report. In its recommendation #4, the P5 report, specifically advocated for "an aggressive R&D program that, while technologically challenging, could yield revolutionary accelerator designs that chart a realistic path to a 10 TeV pCM collider." In the Executive Summary, the report explicitly recommended "targeted collider R&D to establish the feasibility of a 10 TeV pCM muon collider." The report in its Section #2, also referred to the pursuit of the path towards a muon collider as our "Muon shot".

Physics Interests

The physics case of a high energy muon collider has been rapidly developed by the worldwide theory community since the last ESPPU and Snowmass process. Over 100 papers with "muon collider" in the title have been posted directly on the phenomenology arXiv since 2020. The driving force behind this renaissance in muon collider theory is the realistic promise of an alternative to proton colliders for probing significantly higher energies than the LHC, one that is uniquely suited to answering central questions facing the particle physics community. The discovery of a Higgs-like boson at the LHC, without so much as a hint of an explanation for the scale of EWSB or why it even occurs, requires a dedicated exploration that continues beyond Higgs Factories (HF). While e+e- HF represent a technologically-ready first step after the LHC, the unique nature of the Higgs implies that certain questions can only be answered at higher energy. Furthermore, given that in many cases the LHC is already directly probing the scales that HF will indirectly reach, it is entirely plausible that no deviations will be found at HF. Therefore it is crucial to develop technologies that allow us to explore higher energies. This logic extends well beyond the Higgs to include many of the principal candidates for physics beyond the Standard Model. For example, minimal models of WIMP dark matter require new higher-energy colliders and would be discovered by a 10 TeV muon collider, should they be realized in nature. The need for a higher-energy successor to the LHC motivated the global theory community to begin surveying the possibilities for a 100 TeV pp collider long before the recent muon collider efforts. Consequently, many initial physics studies for a 10 TeV muon collider were driven by the same underlying theory motivations as for a 100 TeV proton collider. However, the theory case for a muon collider transcends the boundaries of the energy frontier and continues to be developed.

A muon collider offers both energy and precision, therefore a number of precision studies similar to HF and linear e+e- colliders at high energy have also been performed. The high energy of a 10 TeV muon collider generates larger cross sections for SM processes at "low energy" and enables a continuation of the Higgs precision program beyond HF. Furthermore, it offers an unprecedented window for exploring the Higgs potential with the added energy allowing for significant di-Higgs and tri-Higgs production. Moving forward, the primary focus of muon collider theory is to fully explore the unique capabilities that muon colliders provide beyond the energy frontier studies of a 100 TeV pp collider and HF. These directions follow from the ability to combine energy and precision for the first time: low backgrounds with high luminosity at the highest energies. This enables an indirect reach well beyond the scale achievable by any means for a 100 TeV pp collider in scenarios relating to extensions of the EW sector and the phenomenon of EW symmetry breaking. It also allows new territory to be explored from beneath the scale of EWSB to the collider's kinematic limit in weakly coupled theories. The multipronged investigation of weakly coupled quantum possibilities takes us beyond HF as well as enabling the exploration of new phenomena within the standard model. These latter directions exemplify why a muon collider is unique and more than *just* a possible route to the 10 TeV pCM scale. Muon colliders, if they can be built, are vital tools that can be exploited even if there were other collider options that could reach this energy on a similar timescale. The combination of precision with energy is just one facet of their unique physics potential.

Numerous physics cases that go beyond the standard e+e- and pp paradigms have also been investigated since P5. The most obvious case involves the synergies and potential for understanding the many mysteries surrounding neutrino physics. While neutrino physics has been long intertwined with muon colliders, the prospects for exploiting high-energy neutrino beams, the search for the mass generation mechanism, and the synergy with long baseline experiments and neutrino telescopes all must be revisited in the context of a DUNE/HYPERK-based future. Exploration of the physics potential in other directions such as lepton and quark flavor violation is underway. A muon collider's strength in Higgs physics gives it natural advantages in exploring the phase diagram of electroweak symmetry as well as dark sectors that couple through the Higgs and other portals; the plethora of possibilities leaves much to be explored. Furthermore the development of theory tools and calculations to better understand and illuminate the physics case more clearly is also underway. Theory research related to a muon collider is not specific to the US community and is part of the global exponential growth seen in this direction. The US theory community will continue to support these efforts by helping to lead in new directions, and also by expanding studies in areas where the US has considerable community expertise such as neutrino physics and dark sectors.

R&D Needs and potential US Contributions:

Accelerator R&D:

The accelerator R&D can be divided into three main areas: The machine design effort which will focus on design and simulation of all the subsystems including an end-to-end performance evaluation, the technology development which will focus on key areas such as targetry, magnets and RF cavity development, and finally the muon cooling demonstrator program (described in a separate section below) that addresses complex integration issues.

Starting with the machine design, the US will contribute to an integrated design of all the subsystems, which needs to be developed. This includes an ionization cooling channel design that reaches the desired luminosity as well as accelerator designs that can deliver TeV scale beams with minimum losses; this is an area where the US has particularly strong interests and expertise. Once the generic machine design is established, work is also necessary to evaluate its compatibility with US siting options. Part of the design, especially the accelerator ring, may not be compatible with siting at Fermilab. As a result, we need to examine compatibility with the Fermilab site and tailor the designs accordingly.

In the baseline scheme, muons are produced as tertiary particles from decay of pions created by a high-power proton beam impinging a high Z material target. Fermilab's existing accelerator evolution plan may offer a path to a proton driver for the muon collider, however an R&D program must be developed to define additions to the plan that would produce protons with the desired power and time structure. The SNS accelerator is a close analog to the Muon Collider proton driver. As a result, it can offer a test-bed for demonstrating novel high-intensity technologies such as laser assisted charge exchange injection, bunch compression and space-charge mitigation techniques.

Technology development for target survivability is a crucial area of R&D that the US plans to contribute to. In 2007, a proof-of-principle MERIT experiment at CERN validated this concept with a liquid Hg target. Recent studies indicate that more operational friendly materials such as a solid graphite, liquid metal or fluidized tungsten target are feasible options. Developing high power targets is a central focus for

Fermilab's intensity frontier experiments that can be synergistic with the Muon Collider program. For example, the Mu2e geometry is a lighter analog of the MuC target system, with targets within high field large-bore solenoids. Fermilab also hosts the RaDIATE collaboration that explores targets for LBNF at 2.4MW operation. Hence collaboration with the Mu2e, the Fermilab's neutrino program and with RaDIATE to synergistically conduct target R&D and develop the technology would be very beneficial.

In the area of Normal Conducting RF (NCRF) development, the US will contribute to development of prototype 200-800 MHz cavities for the proposed cooling channels. It's critical to study novel cavity designs or novel methods to maximize their efficiency. For example, using cryogenic copper or breakdown resilient materials such as copper alloy or aluminum. The R&D program should also investigate power sources that can deliver high-peak power (3 MW) and short pulses at hundreds of MHz. In the US, there is expertise in NCRF technology in universities and national labs that could be leveraged. For example, there are synergies with various efforts at SLAC, with groups that have shared research interests in developing advanced NCRF cavities/structures for various applications, and in understanding the physics of RF breakdown under different conditions (including in strong magnetic fields). Muon acceleration will require high-gradient superconducting 325-1300 MHz RF cavities. We need to make conceptual designs of the cavities as needed for accelerator lattices. Then choose cavities to be prototyped, create engineering designs and prepare a prototyping program. There are synergies with the HEP/GARD program and with FCC-ee and potential for collaborations with US universities and US national laboratories.

There are key areas of Magnet technology development that are needed for a 10 TeV muon collider that the US plans to contribute to. Considerable advancements in the magnet design beyond currently available technologies are needed for a 10 TeV muon collider. Three main categories of magnets have been identified as the focus of an R&D program:

1. Fixed-field superconducting solenoids for the target, decay and capture channel, 6D cooling channel and the final cooling channel.
2. Fast ramped normal conducting magnets for the acceleration rings.
3. Fixed-field superconducting accelerator magnets (dipoles, quadrupoles and combined function) for the acceleration rings, collider and interaction region.

Some of these magnets can be built using Nb_3Sn, but others will require HTS technology development. Early R&D could leverage the US Magnet Development Program (MDP) that is generic in nature. The program has recently updated their roadmap to include solenoids and ramped up the development of magnets based on HTS. The US effort is complementary to the IMCC and European Magnet R&D programs. Muon Collider R&D can also benefit from work at the National High Magnetic Field Laboratory, particularly with high field solenoids, and basic high field conductor and magnet R&D.

Detector R&D:

The detector R&D can be divided into two main areas: the detector design effort which will focus on design and simulation of different detector configurations and evaluation of their performances and the technology development which will focus on key areas such as tracking, calorimetry, detector magnet, and data readout.

The environment around the interaction point (IP) presents unique challenges for a detector design. Dedicated shielding around the IP reduces the flux of high-energy electrons from muon decays, with still a large number of low-energy particles - mainly electrons, photons and neutrons, diffusing in the detector. The optimal shape, location, mechanical support and integration/installation will be subject to more detailed multidisciplinary studies. The detector design is heavily influenced by such a background in both its acceptance and technology choices.

High-granularity tracking and calorimetry devices with precision timing capabilities are core capabilities needed to successfully disentangle the physics objects of interest, with very different requirements on the front-end electronics compared to the LHC-era designs. It should be noted that while detector technologies exist that can reach assumed timing and feature-size specs individually, significant further development is needed to integrate, scale, and maintain low power.

Great progress has been made on a conceptual design of both the tracker and calorimeter systems, starting to explore different options and using detailed Geant4-based simulation to assess the physics performance of the conceptual detector designs. Looking ahead, significant work in exploring even more options and down-selecting the most promising solutions is a key goal for the coming years. The development of a complete set of requirements in strong collaboration with accelerator design and physics projection studies is a key milestone along the way, followed by a full set of specifications to identify which of the solutions are best suited.

The US has already a very significant R&D program towards such capabilities and is eager to make progress from technology development to small-scale system prototypes to demonstrate solutions, in synergy with European efforts.

Investigation of other subsystems, from muon spectrometers, to PID detectors to luminosity measurement devices, to a detailed study of the solenoid are also in need of conceptual design where the US can contribute to the international effort. Globally-shared computing resources and development of common software tools is of paramount importance to enable these studies and arrive at a full set of requirements and then specification for the detector design; current US efforts are expected to continue and ultimately grow in support of this direction.

Demonstrator Program:

The physics of ionization cooling has been demonstrated by the Muon Ionization Cooling Experiment (MICE) and the Fermilab Muon g-2 Experiment. Although the principles of ionization cooling are understood, several challenges associated with the cooling technology and its integration exist. For example, operation of NC cavities near to superconducting magnets may compromise the cryogenic performance of the magnet. Installation of absorbers, particularly using liquid hydrogen, may also be challenging in such compact assemblies. Moreover, mitigation approaches to manage the forces within and between the magnet coils need to be developed. To understand and reduce the associated risks, a facility that contains a sequence of ionization cooling cells that closely resemble a realistic ionization cooling channel is envisioned. Such a facility will allow the integrated performance of the systems to be tested as well as provide input, knowledge and experience to design a buildable cooling channel for a MuC. In the next few years, a targeted effort should be carried out towards a conceptual design of a demonstrator for testing cooling technology as well as an effort towards exploration of candidate sites that can host such a facility.

Potential sites for the demonstrator have been identified both in the US and at CERN. In the US, Fermilab is an ideal site for hosting such a Demonstrator because of the existing accelerator infrastructure of a MW-scale proton source that currently enables a strong physics program with neutrino and muon beams, and plans for the evolution of the complex towards a multi-MW proton beam.

IMCC and US Engagement

The US community has been building its efforts in close collaboration with the IMCC. Many US institutions have already joined the collaboration, routinely attend collaboration meetings, and contribute to the efforts of the study. Drafting of a US-CERN agreement that would explicitly enable participation at the labs has begun. The IMCC has US members on its steering board, and US members have been editors on the IMCC Interim Report and its input to the European Strategy process. The leadership of the IMCC has been invited to US meetings, and there is a strong sense of shared purpose across the groups.

The existing structure IMCC reflects the early engagement and funding in Europe. It is hosted by CERN, and closely aligned in structure with an EU-funded project. In order to realize the ambitious plans proposed in the US by P5, global support is needed. US researchers are eager to increase their participation in the IMCC, scientifically as well as organizationally. Discussions are underway around enabling more global engagement, including allowing the US and other interested countries to be better represented in the leadership of the organization.

Timeline and Resources

While awaiting an official response from funding agencies to the relevant P5 recommendations, the US community has remained proactive. It has leveraged various funding sources, including experimental and theory-based grants, LDRD (Laboratory Directed Research and Development), university-specific funding, private sector contributions, and funding from theory institutes to support workshops and research initiatives. It's important to highlight that, at present, the majority of funding for muon collider R&D efforts comes from European sources. Therefore, it is crucial to maximize international collaboration and efforts to ensure the success of these projects.

In the course of the P5 process, the panel requested input from the US Muon Collider community about resource allocation necessary for the muon collider accelerator and detector R&D program. The resource projections were made with the ultimate goal of establishing the technical feasibility of a high-energy muon collider, compatible with potential US-based siting options. This input is briefly summarized in this section.

The proposed muon collider R&D timeline aims to deliver a Technical Design Report (TDR) for the collider within 20 years, aligning with the completion of the LBNF/DUNE Phase-2 construction. This timing, coupled with the synergies and funding profile, makes the muon collider a natural candidate for a post-DUNE US-hosted flagship project in high-energy physics (HEP). The program requires moderate funding levels, which can be sustained alongside the ongoing LBNF/DUNE efforts and the construction of a Higgs Factory. The timeline presented to P5 and shown here differs slightly from the technically constrained IMCC timeline due to considerations regarding the availability of U.S. resources and facilities. However, these differences are small and result in only a short delay of a few years in the delivery of the TDR. This timeline may potentially be shortened slightly, for example depending on funding priorities after LHC upgrades are completed, and therefore is well aligned with IMCC timelines which are also being updated as part of the ESPPU process.

The development of the collider and its underlying detector hardware are closely interrelated, as is the overall detector design. These elements are all intrinsically tied to the program's physics objectives. An R&D and funding strategy that recognizes and reinforces these connections will be especially effective in achieving the scientific milestones needed to demonstrate feasibility.

The program is divided into two primary phases: the **R&D Phase** and the **Demo Phase,** as shown in Figure 1. During the **R&D Phase**, which is expected to last 7-8 years, the accelerator team will focus on developing a reference design through simulation, with smaller-scale studies of key accelerator components. Concurrently, the detector team will work on designs for a 10 TeV detector, the machine-detector interface (MDI), and potential intermediate staging options. Detector component and technology R&D will also occur during this period.

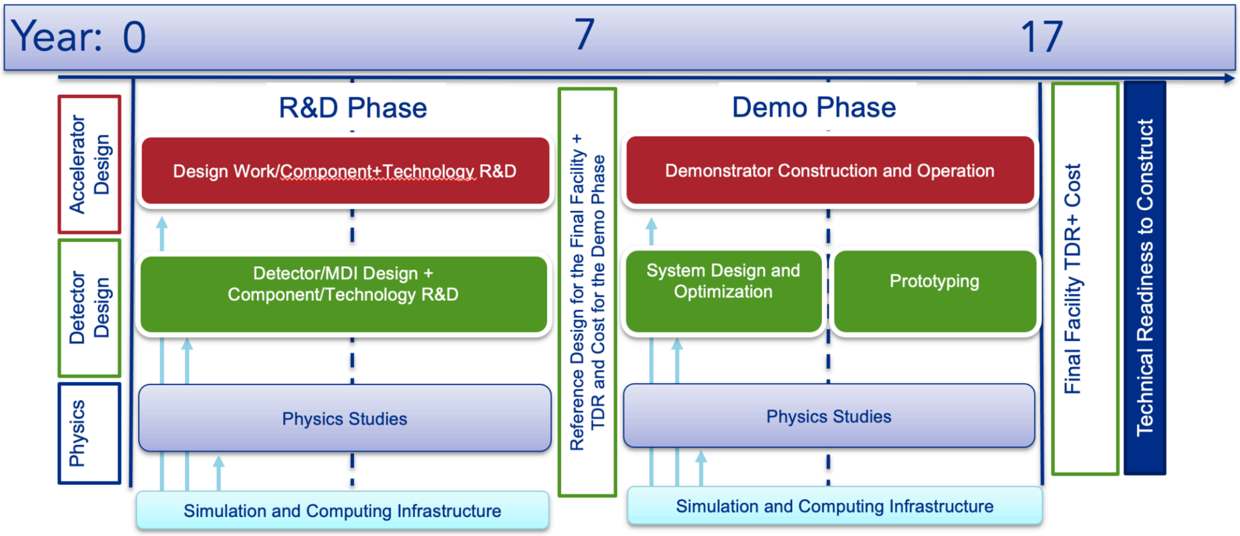

Figure 1: US Muon Collider R&D timeline presented to the 2023 P5. Year 0 indicates the time when significant dedicated R&D funding becomes available in the US. The R&D plan aims to achieve technical readiness for start of construction in under 20 years.

By the end of the **R&D Phase**, the program aims to deliver:

1. A **Reference Design Report (RDR)** for the collider facility, which will include preliminary designs for 3 TeV and 10 TeV detectors.
2. A **TDR** with a detailed cost estimate for the demonstration facility, including a description of the physics that can be studied with the demonstrators.

The FTE (Full-Time Equivalent) and M&S (Material & Services) needs for the **R&D Phase** have been evaluated using both bottom-up and top-down approaches. This was done under the assumption that approximately 50% of the work will be undertaken by the United States, with the remainder handled by the international partners. The accelerator effort needs to ramp up to about 50 FTE/year, while the detector effort will require 35 FTE/year by the end of the R&D Phase. The peak M&S needs for the accelerator and detector during this phase are estimated at $5M and $1.5M per year, respectively (without escalation).

The **Demo Phase** will begin around Years 7-8 and last for approximately ten years. The primary goal of this phase is to construct and operate facilities needed to demonstrate the technology and to address major risks and uncertainties associated with performance of the collider. The accelerator team will focus on building and operating several demonstrators, the largest being the ionization cooling demonstration facility. The detector team will focus on system-level design, explore various options for multiple interaction points, and perform initial prototyping, including the construction of a small-scale detector to demonstrate the required background rejection capabilities with beam.

The funding needed for the **Demo Phase** will depend on the specifications and siting of the demonstrators, as well as the portion of work undertaken by the United States. A more detailed budget profile for the accelerator demonstrators will be developed at the end of the **R&D Phase**, but we estimate that the peak funding requirement for this phase will be on the order of $100M per year in US accounting (consistent with IMCC estimates), corresponding to the construction of the ionization cooling demonstrator. This estimate is based on previous R&D investments for similar mature collider concepts, such as ILC and CLIC. The detector R&D budget is expected to grow by a factor of 2-3 compared to the **R&D Phase**, based on experience with ATLAS and CMS early-stage R&D, construction, and upgrades.

The deliverable at the end of the **Demo Phase** will be a Technical Design Report (TDR) for both the collider facility and the associated detectors, complete with a detailed cost estimate. We expect that during the later stages of the **Demo Phase,** the process of final feasibility study and international negotiations will be launched, ahead of the decision to proceed with the construction.

Realization of the plan above relies on sustained and adequate funding in both the US and Europe, and a close collaboration between the two regions, as outlined in the next section. Potential contributions from other regions of the world would further strengthen the program.

Path Forward for the US

The most effective path forward for developing the conceptual design of the Muon Collider and its associated detectors in the U.S. will involve working closely with the international community. The USMCC is currently being formed, which is an organization of individuals interested in bolstering the science case, designing, and promoting the construction of a multi-TeV muon collider. The organization will bring accelerator, experimental, and theoretical physicists together, integrating new collaborators into the muon collider effort, and organizing work towards maximal impact. The USMCC will lead the work related to siting a muon collider in the United States, while also working with the IMCC in realizing a muon collider, wherever it is built in the world.

The Muon Smashers Guide and other studies from the theoretical particle physics community have had a significant impact on the growing interest in 10-TeV scale physics. There is a strong case for further developing this physics program with greater realism and rigor in event generation and simulation, as well as expanding to include additional areas of physics. Achieving this will require a close collaboration between phenomenologists and experimentalists. We expect that these efforts will yield valuable contributions, helping to establish prospects for measuring standard model Higgs parameters and exploring new physics sectors.

U.S. groups, in collaboration with IMCC, have already started detector studies for a 10-TeV machine. Key aspects such as detector technologies, size, overall geometry, and segmentation are being optimized. These ongoing studies provide a strong foundation, but further work is needed to gaina deeper understanding of the critical factors and conducting a comparative evaluation to develop a viable detector proposal. A particularly important focus is mitigating beam-induced background (BIB). A close collaboration amongst accelerator and simulation experts can yield a more streamlined framework.

The U.S.-based MAP program made significant contributions to the Muon Collider concept. Recently, the IMCC has taken the lead in Muon Collider R&D, following the U.S. divestment from the MAP program. However, much of the expertise at DOE national labs remains intact and could be quickly revitalized to form a strong R&D team. Rebuilding this team would enable the U.S. to participate in the recently funded CERN-based demonstrator efforts. Furthermore, reestablishing the accelerator R&D team will position the US Community to prepare proposals for the US hosted demonstrator once the DOE determines the budget scale.

The U.S. Muon Collaboration, which will include MAP participants and an expanding group of scientists interested in the Muon Collider, presents an excellent opportunity to design a collider for potential U.S. siting. Fermilab stands out as an ideal location for a Muon Collider with a center-of-mass energy target at the desired 10-TeV scale. The synergy with Fermilab's existing and planned accelerator complex, along with its neutrino and CLFV physics programs, further strengthens the case for this investment. Eventually the IMCC and other international committees will form a global consensus on the actual siting and design selection.