PROGRESS TOWARDS A MUON COLLIDER

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Abstract

The muon collider concept promises a unique opportunity to push the energy frontier in particle physics. The large muon mass suppresses synchrotron radiation and allows the acceleration and collision of the beams in rings and the use of technology more similar to hadron colliders. Muons are point-like, in contrast to protons, and thus can achieve a similar physics reach with less energy, allowing for a more compact machine. However muons have a lifetime of only 2.2 microseconds at rest. The muon beam thus needs to be cooled and accelerated rapidly to maximise the luminosity, which creates several technology challenges. The International Muon Collider Collaboration is implementing an intense R&D programme to address these challenges and to develop the concept maturity. The paper will highlight the key challenges, summarise the progress of the work and the proposed R&D plan for the next decade.

INTRODUCTION

The muon collider is a unique, high-energy collider concept that combines the high-energy reach of a hadron collider with the precision of a lepton collider, opening the path to multi-TeV parton-parton collisions in a compact footprint. Two single-bunch muon beams of opposite charge are produced from a high-power proton driver, ionisation-cooled, accelerated rapidly, and brought to collision in a collider ring. The short muon lifetime of 2.2 µs at rest is the central technical challenge: the beams must be cooled and accelerated to multi-TeV energies on a timescale set by their own decay. The muon collider concept was developed by the U.S. Muon Accelerator Program (MAP) until 2017 [1]. It is now being progressed by the International Muon Collider Collaboration (IMCC) [2,3], formed following the previous European Strategy for Particle Physics Update (ESPPU), which recognised the importance of studying the muon collider as a potential path for the future of particle physics. This direction was subsequently reinforced by the U.S. Particle Physics Project Prioritisation Panel (P5), reflecting broad international support for the development of the concept. The scientific potential of the muon collider and the innovative research it demands have motivated a growing community, including many early career researchers, enabling the IMCC to pursue an active and innovative R&D programme to advance the muon collider design and underlying technologies. The collaboration provided a comprehensive input [4, 5] to the 2026 update of the European Strategy for Particle Physics, including an assessment of the concept and the technologies, a ten-year R&D plan, and implementation considerations. It also released the Consolidated Parameters Report [6] in October 2025, establishing a coherent baseline for the 10 TeV design across all subsystems. This paper summarises the current status of the design and the progress of the R&D programme. Detailed discussions of the latest developments are presented in dedicated contributions to this conference.

THE MUON COLLIDER CONCEPT

The baseline muon collider design targets a centre-of-mass energy of 10 TeV and an integrated luminosity of 10 ab^{-1} [2, 6]. An initial stage with implementation around 2050 is also under consideration. The schematic layout of the collider is shown in Fig. 1 and contains the following key areas (in colour-coded boxes, from left to right):

- The proton driver produces a short, high-intensity proton pulse.
- The pulse impinges on a target and produces pions. The decay channel guides the pions and forms a beam with the resulting muons via a buncher and phase rotator system.
- Several cooling stages reduce the longitudinal and transverse emittance of the beam through ionisation cooling, using a sequence of absorbers and RF cavities embedded in a high magnetic field.
- A linac and two recirculating linacs accelerate the beams to 63 GeV, followed by a chain of rapid-cycling synchrotrons reaching either 1.5 TeV or 5 TeV.
- The beams are injected at full energy into the collider ring, where they circulate and collide within the detectors until they decay.

Table 1 summarises the key target parameters for the muon collider, in two stages, for both a site-independent design and a specific implementation at CERN reusing existing infrastructure. The site-independent parameters at 3 TeV and 10 TeV centre-of-mass energy are set to probe the limits of each technology and design. If they can be fully met, the integrated luminosity goal is reached within five years of full operation, or 2.5 years with two detectors, leaving margin for further design and technology studies and for a realistic luminosity ramp-up.

Implementations at CERN and Fermilab are under consideration. At CERN, the existing SPS and LHC tunnels could host the high-energy muon acceleration chain, allowing a centre-of-mass collision energy of up to 7.6 TeV with a practical initial stage at up to 3.2 TeV, depending on the layout.

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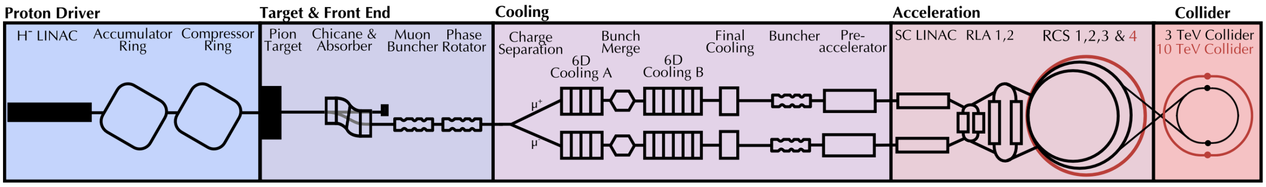

Figure 1: Conceptual layout of the muon collider.

Table 1: Consolidated target parameters for a muon collider at different energies. The site-independent scenario uses Nb_3Sn technology in the collider ring that is consistent with a project implementation by 2050. The CERN scenario reuses the SPS and LHC tunnels and assumes an 11 km collider tunnel. The estimated luminosity refers to the value that can be reached if all target specifications can be met, including beam–beam effects [6].

			Site independent		**CERN**	
Parameter	**Symbol**	**Unit**	**Stage 1**	**Stage 2**	**Stage 1**	**Stage 2**
Centre-of-mass energy	E_{cm}	TeV	3	10	3.2	7.6
Target integrated luminosity	$\int \mathscr{L}_{\mathrm{target}}$	ab^{-1}	1	10	1	10
Estimated luminosity	$\mathscr{L}_{\mathrm{est.}}$	$10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$	2.1	18	0.9	7.9
Collider circumference	C_{coll}	km	4.5	11.4	11	11
Collider arc peak field	B_{arc}	T	11	14	4.8	11
Collider dipole technology			Nb_3Sn	HTS	NbTi	Nb_3Sn or HTS

The significant reduction of civil engineering and the associated environmental impact may justify the slight reduction in physics reach. An upgrade path towards 10 TeV based on fast-ramping HTS magnets in the muon acceleration is also under study, contingent on further R&D to demonstrate the feasibility of this option.

STATUS OF DESIGN AND TECHNOLOGIES

Building on the foundation laid by MAP, the IMCC has progressed the design of the muon collider subsystems and the underlying technologies, addressing the technical challenges in a coherent international effort. The collaboration's work covers physics potential, detector design, and accelerator design and performance, assessing the maturity of the technologies and producing the critical designs needed to address each challenge. A detailed report of the status was provided as input to the 2026 ESPPU [4, 5], including an assessment of the concept and the technologies. The Consolidated Parameters Report [6], released subsequently, established a coherent baseline for the 10 TeV design. The remainder of this section summarises the overall status and recent progress.

Proton Driver

The proton driver must deliver a short, intense proton pulse containing 5×10^{14} protons within 2 ns at 5 Hz for muon production. The baseline scheme consists of an H^- linac, an accumulator ring and a compressor ring, with parameters and lattice studies developed for two beam energy (power) options: 5 GeV (2 MW) and 10 GeV (4 MW) [6]. Recently, significant focus has been placed on improving the modelling of space-charge effects in the compressor, where the high charge density drives the most demanding regime of the complex [7]. The simulations have been upgraded to a full 3D particle-in-cell model and provide insight into the mechanisms underlying transverse emittance growth at the end of the compression cycle. An alternative compression scheme has also been proposed and studied (Fig. 2), in which an energy chirp imposed on the bunch train by two detuned RF cavities removes the need for a dedicated accumulator ring [8]. Compression to the 2 ns target bunch length is feasible for the baseline scheme but not yet for the chirp-based scheme. Bunch compression experiments at the CERN PS and the SNS will provide experimental insight into the compressor simulation studies.

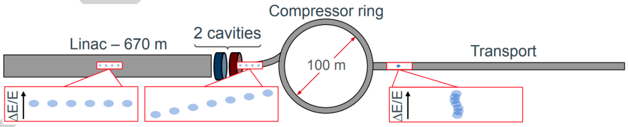

Figure 2: Conceptual layout of an alternative proton complex based on an energy-chirp compression scheme.

Target

The baseline 2 MW-class target system consists of a graphite rod immersed in a 20 T solenoid field (Fig. 3). The target assembly – including a helium-cooling system – and the magnet shielding have been designed in detail, and the pion yield has been optimised through dedicated FLUKA simulations. Higher-power options are also being studied. Actively-cooled graphite, powdered tungsten and liquid lead target concepts [9] are being considered as candidates for operation at 4 MW beam power. Studies of spent proton beam extraction are also progressing. A non-negligible fraction of the protons does not interact in the target and would otherwise deposit substantial power in the downstream chicane solenoids. For the 2 MW configuration, an extraction opening in the middle of the chicane has been developed using solenoids of different diameters to create an aperture for the un-deflected protons. For the 4 MW case, an alternative scheme based on early extraction immediately downstream of the target is under investigation. In this scheme, the proton beam is injected at an angle with respect to the solenoidal axis, enabling radial extraction through an aperture between the capture solenoids. Preliminary FLUKA simulations compare both options in terms of power deposition, dose, and material damage [10].

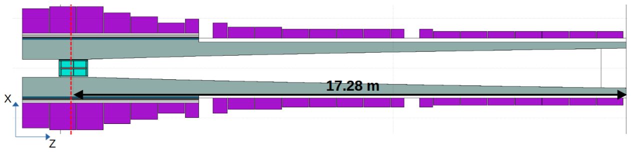

Figure 3: Geometrical model of the target region implemented in FLUKA simulations (X–Z view). The solenoid coils are shown in purple, the shielding in grey, and the target is enclosed within a helium-filled vessel shown in cyan.

Muon Cooling

The muon cooling system reduces the 6-D beam emittance to the values required to maximise luminosity at the collider, through a sequence of high-field solenoids, RF cavities and energy-absorbing material. The current baseline cooling complex consists of a charge separation section, a 6-D cooling system based on rectilinear cooling cells (Rectilinear A and B sections, with bunch merging in between), and a final cooling section which further cools the beam transversely at the expense of longitudinal emittance. The 6-D cooling and final cooling lattices have been substantially developed, delivering transverse and longitudinal emittances of 22.5 µm and 7.7 eV ms respectively at the end of the chain, with the overall system exceeding target performance (Fig. 4) [11, 12]. The longitudinal emittance is significantly below the design value, providing useful margin and potential benefits for the downstream accelerator chain and the collider ring. Ongoing optimisation focuses on incorporating hardware constraints and collective effects [13, 14], as well as improving stage-to-stage matching [15]. The simulation tools (BDSIM [16] and RF-Track) continue to be developed, and alternative cooling schemes are under study, including simultaneous cooling of both charge signs and a final cooling concept based on wedge absorbers [17].

High-Energy Acceleration

The high-energy acceleration, following initial acceleration in a single-pass linac and a pair of multi-pass recirculating linacs, is provided by a chain of four rapid-cycling synchrotrons (RCS1–RCS4), accelerating two counter-rotating muon bunches from 63 GeV to either 1.5 TeV (after RCS3) or 5 TeV (after RCS4) [6]. Recent studies have focused on understanding and mitigating limitations in the complex. The mismatch between the beam energy and the ramped fields of the pulsed magnets has been studied in detail, showing that it induces transverse orbit oscillations and strong β-beating, leading to emittance growth if uncorrected. Mitigation strategies based on distributing the RF system over more stations around the ring are being developed [18]. In parallel, the longitudinal matching between successive RCS stages has been re-optimised by adjusting the synchronous phase and modifying the aspect ratios of the extraction and injection RF buckets, improving control of longitudinal emittance growth across the chain [19]. Intensity effects associated with the counter-rotating beams accelerated simultaneously by the same RF cavity have also been investigated. Multi-turn wakefields from the fundamental cavity mode have been found to cause emittance growth in RCS1–RCS2 and of beam losses in RCS3–RCS4, informing the development of dedicated mitigation strategies [20].

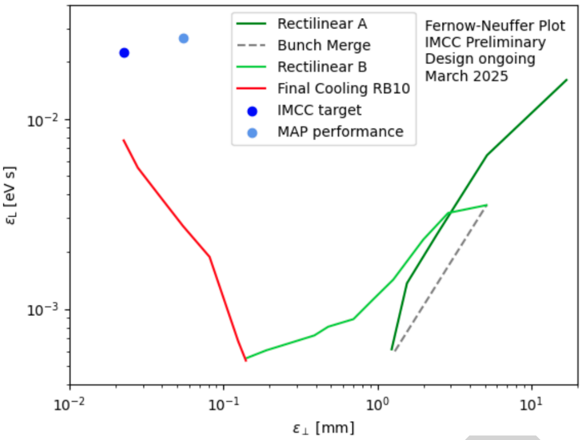

Figure 4: Current cooling performance estimate for the muon cooling system. Optimisation is ongoing. Best performance so far yields $\varepsilon_\perp$=22.5 µm, $\varepsilon_\parallel$=7.7 eV ms.

Collider Ring

The collider ring at 10 TeV centre-of-mass energy must deliver a short bunch with a large momentum spread to maximise the luminosity, with a β^* of 1.5 mm. The dominant challenges are control of chromatic aberrations and the mitigation of the neutrino flux. The latter is addressed through a controlled, time-dependent vertical deformation of the beam trajectory and the collider ring. By incrementally stepping this deformation in time, the resulting neutrino flux is spread over a wide vertical fan, reducing peak radiation levels. A design framework for the required lattice deformations has been established, and beam dynamics studies show negligible performance impact in regular the arc cells. The effects in the chromatic correction and matching sections of the ring (which are also part of the collider arcs) are under further investigation [21]. In addition, a first joint optimisation of the ionisation cooling channel and the collider ring indicates that a shorter cooling system can result in a luminosity gain, although further optimisation is required to fully reach the target [22].

Collective Effects

Collective effects studies have been conducted across multiple subsystems of the muon collider, to more accurately model the behaviour of the high-intensity muon beams. In the final cooling channel, intra-beam scattering and space-charge effects in the first three stages of the final cooling have been simulated, showing a measurable impact on the system cooling performance. A benchmarking exercise of the WAKIS code against analytical solutions for longitudinal and transverse wake potentials in a resistive-wall is ongoing. Single-bunch transverse stability across the full RCS chain has been studied with TESLA-cavity impedance models. Together with the space-charge studies discussed in earlier sections, these studies inform the design choices and constraints across the complex.

Site Placement

Muon decays in the collider ring produce high-energy neutrinos that have a non-negligible probability to interact in material close to Earth's surface, far from the collider. The environmental impact of the neutrino-induced showers must be diluted to a level comparable to that of the LHC. A mover system in the collider arcs has been proposed to displace the magnets vertically over time and to fan the neutrino flux, while the impact of the flux from the straight section near the interaction point can be mitigated through the collider orientation. Detailed FLUKA modelling of the neutrino dose, complemented by dedicated tools (GeoProfiler and a placement optimisation framework) for mapping its impact, has identified a favourable orientation for an implementation at CERN. Recent work has characterised the neutrino flux emerging from the straight sections in detail, confirming the high collimation and intensity of the beam and providing input for both mitigation strategies and potential downstream application [23]. Preliminary results indicate that the environmental impact can be reduced to negligible levels, with further studies of flux mitigation and placement optimisation ongoing.

R&D PROGRAMME

A comprehensive R&D programme is required to bring the muon collider concept to the maturity needed to initiate an approval process. The proposed programme spans ten years and addresses the items that drive the project timeline, such as the muon cooling technology, the most challenging magnets, and the start-to-end facility design. The accelerator design effort will focus on completing the start-to-end design of the facility, in order to validate and optimise its performance, cost, power consumption and risk. This will be conducted in the first phase of the programme, and it will be used to guide the component development. The muon cooling technology demonstration programme is on the project critical path. It will develop the components such as the HTS solenoids, the cavities and the absorbers. The programme comprises the construction of RF test stands to establish the achievable RF gradient in the presence of high-field solenoids, the implementation and beam-test of cooling cell modules, and ultimately the operation of a multi-cell cooling channel demonstrator with beam. The first stage requires test infrastructure with high-field magnets, which is a particularly time-critical activity. New detector technologies suitable for low-intensity muons beams must also be developed for the instrumentation of the cooling channel. The magnet programme will establish the performance of the most challenging magnets through the construction and test of models and prototypes. It will focus on HTS solenoids for the muon production target and the muon cooling, and on a model of the collider ring dipoles to demonstrate the field at large aperture. The HTS technology in particular has strong synergies with other applications in society, such as fusion reactors, and industry has indicated readiness to engage. The R&D programme has been reviewed and supported by the International Advisory Committee (IAC) of the IMCC, with suggestions for minor improvements. The programme requires sustained funding and a coordinated international effort to be carried out within the proposed timeline. In the U.S., a National Lab Accelerator Study Group for the Muon Collider has been established to identify the accelerator R&D challenges and to assess how the U.S. national laboratories can best contribute to the effort, building on existing IMCC planning.

MUON COOLING DEMONSTRATOR

The muon cooling demonstrator is an essential component of the muon collider R&D programme. Its purpose is to demonstrate the successful integration of the cooling equipment, the operation of the cooling equipment with beam, and the delivery of the required beam-physics performance. The programme is staged, beginning with RF test stands to characterise the achievable gradient in high-field solenoids, progressing through one-cell and multi-cell modules, and culminating in the operation of a full cooling line with beam.

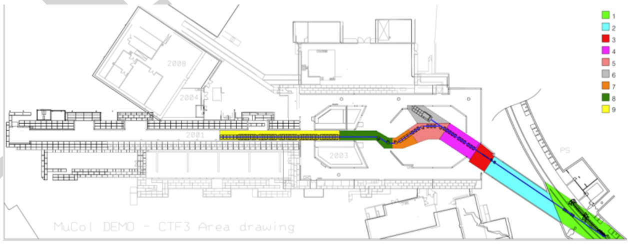

Figure 5: Proposed layout of the muon cooling demonstrator at the CTF3 site. Proton extraction (light green), Proton Transfer line (cyan), Target area (red), pion decay channel (magenta), magnetic chicane (peach), proton and pion dump (grey), beam preparation system (orange), matching section (dark green), cooling cell channel (yellow).

Candidate sites at CERN, Fermilab, and other laboratories have been identified. Two siting options at CERN that use existing infrastructure (the TT7 tunnel and the CTF3 building) have been studied, including lattice design, engineering integration and cost-estimation. Both configurations would use a low-power proton beam ($\leq 10\,\mathrm{kW}$) from the CERN PS. The CTF3 option (Fig. 5) requires significantly less civil engineering, making it a cost-effective solution capable of supporting all stages of the programme. A similar site study has been approved at Fermilab. Preliminary designs of the muon source and transport line have identified no critical issues and highlight the relatively low beam intensity delivered to the cooling channel (of order 10^6 muons per bunch). A first radiation protection study for the CTF3 target area has established an initial shielding configuration [24]. The cooling lattice design, based on a cell concept similar to the Stage 5 Rectilinear B system, is mature and has been refined through iterative integration of the beam dynamics and hardware designs [25]. In the first phase of the programme, test stands integrating 3 GHz RF cavities and superconducting solenoids will be developed to test the RF breakdown limit in a 7 T magnetic field. The construction of RF test stands remains a critical near-term priority that requires adequate resources, with preparations underway at INFN and SLAC.

6-D Cooling Cell

The demonstrator 6-D cooling cell is composed of a LiH material absorber, to reduce both longitudinal and transverse momenta with minimal particle loss, an RF structure of three 704 MHz cavities to restore the longitudinal momentum of the particles, and HTS solenoids, which focus the beam and maintain a small beta function at the absorber position. The key engineering challenges arise from their compact integration. Detailed electromagnetic and mechanical designs of the RF structure [26,27] and of the non-insulated HTS solenoids operating at 20 K have been developed, and a preliminary engineering design of the cell has been achieved [28]. The cell design is based on an inter-cell cryostat solution, a compact architecture that contains the magnetic forces within the cold mass while decoupling the RF and absorber assemblies at room temperature. The design of a cooling module containing five cells has also been completed, including a support structure to manage the imbalance of forces at the ends of the module (Fig. 6). In parallel, a reduced-diameter (250 mm) HTS solenoid has been designed for operation on a 3 GHz RF test stand [29]. The collaboration is now ready to start prototyping and testing.

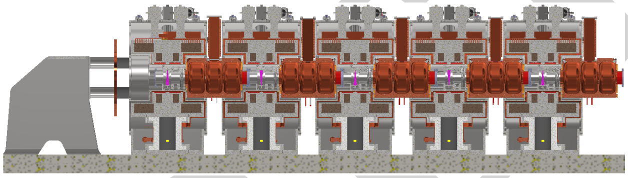

Figure 6: Engineering view of a sequence of cooling cells, showing the HTS solenoids, RF cavities and absorbers and their integration using an inter-cell cryostat solution. A support structure designed to manage the force imbalance in the first/last inter-cell cryostat module is also shown.

CONCLUSION

The muon collider represents a novel and transformative approach to energy-frontier accelerators, uniquely combining the reach of hadron colliders with the precision of lepton machines within a compact footprint. Continued progress delivered by the IMCC has strengthened the technical basis of the concept and increased confidence in its feasibility. The next phase of development is centred on an essential and targeted experimental R&D programme, including the muon cooling demonstrator and high-field HTS magnet prototyping, aimed at validating the most challenging aspects of the design and associated technologies, enabling the transition towards a Conceptual Design Report. This programme has strong synergies with other fields, notably applications of high-field superconducting technologies in areas such as fusion. As the design matures, the muon collider continues to provide a prolific ground for innovation across accelerator physics and technology. Its open challenges, together with the breadth of the R&D programme, offer a compelling framework for sustained international collaboration and for the development of the next generation of researchers.

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REFERENCES

[1] M. A. Palmer and K. Long, Eds., "Muon accelerators for particle physics (MUON)", *J. Instrum.*, special issue, 2016–2021. Article collection: Muon Accelerator Program (MAP). `https://web.archive.org/web/20210505140022/http://map.fnal.gov/`

[2] C. Accettura *et al.*, "Towards a muon collider", *Eur. Phys. J. C*, vol. 83, p. 864, 2023; Erratum: *Eur. Phys. J. C*, vol. 84, p. 36, 2024. doi:10.1140/epjc/s10052-023-11889-x

[3] C. Accettura *et al.*, "Interim report for the International Muon Collider Collaboration (IMCC)", CERN, Geneva, Switzerland, Rep. CERN-2024-002, Sep. 2024. doi:10.23731/CYRM-2024-002

[4] The International Muon Collider Collaboration, "The Muon Collider: report to the European Strategy for Particle Physics 2026 update", 2025. `https://edms.cern.ch/document/3284682/1`

[5] C. Accettura *et al.*, "The Muon Collider", 2025, arXiv:2504.21417 [physics.acc-ph]. doi:10.48550/arXiv.2504.21417

[6] C. Accettura *et al.*, "Consolidated parameters report", MuCol Milestone Report MS7, Oct. 2025, arXiv:2510.27437 [physics.acc-ph]. doi:10.5281/zenodo.17476875

[7] N. Milas *et al.*, "Improved space-charge simulation studies for the Muon Collider proton compressor", presented at IPAC'26, Deauville, France, May 2026, paper WEP5116, this conference.

[8] J. Holmberg *et al.*, "Investigations of a novel bunch compression technique for hadron accelerators", presented at IPAC'26, Deauville, France, May 2026, paper THP4042, this conference.

[9] S. Candido *et al.*, “Conceptual comparison of liquid lead flow configurations for a muon collider”, presented at IPAC’26, Deauville, France, May 2026, paper MOP7137, this conference.

[10] J. Manczak *et al.*, “FLUKA studies of spent beam extraction in the muon collider target system”, presented at IPAC’26, Deauville, France, May 2026, paper WEP1012, this conference.

[11] R. Zhu *et al.*, “Updated design of rectilinear 6D and final cooling channels for a muon collider”, presented at IPAC’26, Deauville, France, May 2026, paper WEP4655, this conference.

[12] R. Zhu, C. Rogers, J. Yang, H. Zhao, C. Guo, and J. Li, “Design method, performance evaluation, and tolerance analysis of the rectilinear cooling channel for a muon collider”, *Phys. Rev. Accel. Beams*, vol. 28, p. 041003, 2025. doi:10.1103/PhysRevAccelBeams.28.041003

[13] C. Barbagallo *et al.*, “RF cavities and beam loading in the Muon Collider rectilinear cooling channel”, presented at IPAC’26, Deauville, France, May 2026, paper WEP1001, this conference.

[14] P. D. Valdor *et al.*, “Impact of intrabeam scattering and space-charge in the Muon Collider cooling channel”, presented at IPAC’26, Deauville, France, May 2026, paper MOP1100, this conference.

[15] P. D. Valdor *et al.*, “Analytical solenoid matching routines with coolpy”, presented at IPAC’26, Deauville, France, May 2026, paper TUP3001, this conference.

[16] S. Alden *et al.*, “Progress and developments of beam delivery simulation (BDSIM)”, presented at IPAC’26, Deauville, France, May 2026, paper WEP5138, this conference.

[17] I. Karaaslan *et al.*, “Dispersion suppression for wedge-based final cooling at a 10 TeV muon collider”, presented at IPAC’26, Deauville, France, May 2026, paper WEP1345, this conference.

[18] L. Soubirou *et al.*, “Impact of rapid acceleration on beam dynamics in the rapid-cycling synchrotrons of a muon collider”, presented at IPAC’26, Deauville, France, May 2026, paper MOP1094, this conference.

[19] E. Lamb *et al.*, “Optimisation of beam transfer between RCS in the Muon Collider”, presented at IPAC’26, Deauville, France, May 2026, paper WEP1013, this conference.

[20] L. Thiele *et al.*, “Modelling of counter-rotating multi-turn wakefields in the muon collider RCS chain”, presented at IPAC’26, Deauville, France, May 2026, paper THP4038, this conference.

[21] M. Vanwelde *et al.*, “Vertical deformation of the 10 TeV muon collider ring for neutrino flux mitigation”, presented at IPAC’26, Deauville, France, May 2026, paper MOP1045, this conference.

[22] M. Vanwelde *et al.*, “Dependence of muon collider luminosity on ionization cooling performance”, presented at IPAC’26, Deauville, France, May 2026, paper MOP1025, this conference.

[23] D. Calzolari *et al.*, “Neutrino fluence estimates for forward experiments at a 10 TeV muon collider”, presented at IPAC’26, Deauville, France, May 2026, paper MOP1044, this conference.

[24] “Refined design of the front-end complex for a muon cooling demonstrator at CERN”, presented at IPAC’26, Deauville, France, May 2026, paper MOP1105, this conference.

[25] “Simulation and study of the Muon Cooling Demonstrator rectilinear channel in BDSIM”, presented at IPAC’26, Deauville, France, May 2026, paper MOP1048, this conference.

[26] D. Giove *et al.*, “Study and design of a 3-cell 704 MHz structure for the MC Demonstrator RF cavity”, presented at IPAC’26, Deauville, France, May 2026, paper WEP1011, this conference.

[27] D. Giove *et al.*, “Study and design of thin windows for the MC Demonstrator RF cavity”, presented at IPAC’26, Deauville, France, May 2026, paper WEP1006, this conference.

[28] G. Scarantino *et al.*, “Preliminary engineering design of the cooling cell for the Muon Collider cooling demonstrator”, presented at IPAC’26, Deauville, France, May 2026, paper WEP1010, this conference.

[29] G. Scarantino *et al.*, “Engineering design of the HTS solenoids for the 6D cooling demonstrator and RF test facility for the Muon Collider”, presented at IPAC’26, Deauville, France, May 2026, paper MOP7080, this conference.