EU Design Study Proposal

International MUON Collider Collaboration

Università degli Studi di Padova

MuCol WP2

Physics and Detector Performance Requirements

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WP2 Description

- Provide performance specifications for a detector at 3 TeV and 10 TeV center-of-mass energies.
- Determine detector performance by assessing its sensitivity to major physics processes beyond the Standard Model and precision Standard Model measurements.
- Design based on realistic targets for the technologies and include the impact of background and its mitigation.

WP2 Description

- Beam-induced background will be studied comparing different configurations of the interaction region and shielding around it. Iterative process in collaboration with WP5 -high energy complex- until an optimized IR is obtained.

- Algorithms development for event reconstruction in each sub-detector by exploiting 5D event reconstruction to mitigate the effect of the irreducible beam-induced background.

- Detector and algorithms performance determination by measuring the reach on the most challenging physics cases: Standard Model precision measurements and New Physics searches with discovery potential.

Task 2.1 Design of detector configurations at √s=3 TeV and √s=10 TeV with the optimised interaction regions

(**UNIPD**,INFN, Sussex, ISU)

This task will study the beam-induced background effects on the detector components produced with different interaction region configurations. Feedbacks will be given to WP5, high energy complex, where the IR is designed to optimise background fluxes and the shielding configuration. This will be done in an iterative way until an optimised IR is defined and the relative detector configuration proposed.

Task 2.2 Design and implementation of event reconstruction algorithms in 5D at √s=3 TeV and √s=10 TeV

(DESY,CERN,LIP,UNIPV,CEA**)**

This task will focus on developing reconstruction algorithms exploiting 3D position, energy, and timing measurements to mitigate beam-induced background and perform tracking and calorimetry clustering. Leveraging on the developments made for future colliders, this task will explore machine learning solutions and parallel computing, both for real-time event processing and for offline analysis, taking into account the specific challenges of a muon collider (e.g., particle tracking in the forward region).

Task 2.3 Evaluate detector performance at different collision energies by using major physics processes

(**INFN**,DESY,CN,UNIPV, Sussex, UNIPD,CEA)

This task will explore the detector performance of a muon collider operating at different collision energies. Exploiting an optimal design of the interaction region (Task1) and advances in event reconstruction (Task2), the detector performance will be determined by evaluating the reach of major physics processes for Standard Model measurements, and for searches for physics beyond the Standard Model.

Table 3.1b

Work package number	2		**Lead beneficiary**		UniPD					
Work package title	Physics and Detector Performance Requirements									
Participant number										
Short name of participant	UniPD	CERN	INFN	CEA	DESY	Sussex	LIP	ISU	CN	UniPV
Person months per participant:	16	8	16	18	8	8	6	4	4	8
Start month	1			**End month**	48					

Table 3.1c

Deliverable (number)	Deliverable name	Work package number	Short name of lead participant	Type	Dissemination level	Delivery date (in months)
2.1	Beam-induced background and detector configuration	2.1	UniPD	Data	PU	30
2.2	Detector performance by using physics processes	2.2	DESY	R	PU	36

Table 3.1d List of Milestones

Milestone number	Milestone name	Related work package(s)	Due date (in month)	Means of verification
2.1	Training on detector design and physics performance tools	2.1, 2.2, 2.3	6	Training material
2.2	Workshop on MDI and IR design	2.1, 2.2, 5.1,5.5,5.6	12	Internal note on workshop summary
2.3	Release of simplified detector performance model (DELPHES card or/and similar format)	2.1, 2.2	18	Availability of the released format on the project web site
2.4	Workshop on detector design and physics performance with a public lecture on Muon Collider	2.1, 2.2, 2.3	24	First draft of Internal note on detector & physics
2.5	Publication of open access report of detector performance with major physics process at several CoM energies	2.1,2.2,2.3	48	Peer reviewed paper

Table 3.1e: Critical risks for implementation

Description of risk (indicate level of (i) likelihood, and (ii) severity: Low/Medium/High)	Work package(s) involved	Proposed risk-mitigation measures
Delay in the availability of 10 TeV centre-of-mass energy IR lattice (low likelihood, high severity)	2	Study a procedure to scale the 3 TeV centre-of-mass results to high energy with much less accuracy
Lack of computing resources to fully simulate the beam-induced background for all the IR configurations (likelihood:low, medium severity)	2	Ask the US and China associated members to contribute with computing resources

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Comments?