

**Memorandum of Agreement**  
**for the execution of the MUonE Test Run**  
**between the**  
**CMS-Tracker Group (CMS-TK)**  
**and the**  
**MUonE Collaboration (MUonE)**  
**collectively named the Signatories**

**Scope**

This Memorandum of Agreement (MoA) between CMS-TK and MUonE is a collaborative agreement between scientists and does not constitute a legal contractual obligation on the part of the Signatories.

This MoA documents the terms of agreement between CMS-TK and MUonE for the provision by CMS-TK of materials and services towards the effective operation of the MUonE Test Run and outlines the foreseeable terms of a possible future Memorandum of Understanding (MoU) to be established between CMS and MUonE if and when MUonE becomes an approved experiment at CERN.

**Introduction**

In view of the High-Luminosity phase of LHC, CMS-TK has undertaken the construction of a new, upgraded, Tracker detector which will be installed during Long Shutdown 3, completely replacing the present detector; this is known as the Phase-2 upgrade of the CMS Tracker<sup>1</sup>. The Phase-2 CMS Tracker is a modular detector made of several thousands of modules with a few different designs and geometries, all comprising strip and/or pixel silicon sensors. One of the types of silicon modules is the so-called “2S” module<sup>2</sup>.

In 2019, a collaboration of scientists submitted to the CERN SPSC a Letter of Intent<sup>3</sup> for a new experiment, named MUonE, which intends to perform a high precision measurement of differential  $\mu e \rightarrow \mu e$  cross section ( $d\sigma/dq^2$ ) with a 160 GeV  $\mu$  beam on Be target, aiming at space-like determination of the running of  $\alpha$ , and in particular of the hadronic component  $\Delta\alpha_{had}$ , with a statistical accuracy of just 0.3%. The MUonE project includes a tracking system that MUonE plans to equip with 240 CMS-TK “2S” modules<sup>4</sup>. MUonE proposed to perform a test run in 2021 with a reduced-size demonstrator detector, whose tracking systems shall comprise only 18 CMS-TK “2S” modules<sup>5</sup>. The CERN SPSC approved a Test Run of MUonE with the demonstrator detector for late 2021 in its 21 January, 2020, session.

<sup>1</sup> “The Phase-2 Upgrade of the CMS Tracker”, CERN-LHCC-2017-009; CMS-TDR-014

<sup>2</sup> “The Phase-2 Upgrade of the CMS Tracker”, CERN-LHCC-2017-009; CMS-TDR-014, page 30 and following

<sup>3</sup> “Letter of Intent: the MUonE project”, CERN-SPSC-2019-026; SPSC-I-252

<sup>4</sup> “Letter of Intent: the MUonE project”, CERN-SPSC-2019-026; SPSC-I-252, pages 9-13

<sup>5</sup> “Letter of Intent: the MUonE project”, CERN-SPSC-2019-026; SPSC-I-252, page 51



## Agreement terms

This paragraph

- details the CMS-TK commitment towards MUonE (what CMS-TK provides to MUonE, under which conditions);
- addresses material (ownership of parts) and intellectual (publications) property issues;
- regulates the financial aspects of the provision of “2S” modules to MUonE by CMS-TK.

### **1. Material and service provision**

- 1.1. CMS-TK will deliver to MUonE 20 (twenty) fully functional modules for the demonstrator detector after single-module test, along with the test results.
- 1.2. These 20 modules will be built with prototype hybrid electronic circuits procured by CMS-TK in 2020.
- 1.3. Information and support for integration of the modules in the detector, detector optimization and operation are provided by CMS-TK to MUonE on best-effort basis.
- 1.4. In case of schedule problems, plans and priorities will be discussed and agreed between the CMS-TK Upgrade management and the MUonE management, with the understanding that commitments by CMS-TK to MUonE must have zero or positive interference with the Tracker upgrade project.

### **2. Material property and financial aspects**

- 2.1. MUonE will cover the costs for the procurement of module components. These costs, at the time of writing, are listed in **Appendix**. It is understood that the actual costs when each component is procured may differ, although large discrepancies are not anticipated.
- 2.2. Module assembly and quality control will take place at Institutes supporting both CMS-TK and MUonE.
- 2.3. The modules will become MUonE property.

### **3. Intellectual property and publications**

#### *3.1. Preamble:*

The MUonE detector will be heavily based on developments carried out by CMS-TK. As a matter of fact, the first operation of “2S” modules for physics will be in MUonE, not in CMS. Therefore, intellectual property on these modules must be adequately recognized and acknowledged by MUonE in its publications as well as in other channels of communication of the MUonE scientific results.

#### *3.2. Journal publications:*

3.2.1. The MUonE and CMS-TK commit to jointly write and publish a paper on the performance of “2S” modules [henceforth: “2S module performance paper”] as



soon as an adequate data sample is collected.

3.2.1.1. Such a paper shall be published before any other paper describing the MUonE tracking system or tracking performance.

3.2.1.2. Such a paper, as well as any further paper that should discuss performance of “2S” modules, will be signed by the full CMS-TK author list and the MUonE author list.

3.2.1.3. For its preparation, or the preparation of any further paper discussing performance of “2S” modules, CMS-TK will be granted access to the MUonE data, so that CMS-TK members can contribute to obtaining results on the 2S module performance.

3.2.2. Any other MUonE technical paper related (or partially related) to the tracking system shall contain an acknowledgement to CMS in the abstract, and cite the “2S module performance paper”.

3.2.3. All other MUonE papers (physics results or technical papers on other subdetectors) shall contain a standard acknowledgment to CMS at the end of the paper.

3.2.4. In case issues with the performance of the modules appear at any point in time during the operation of the MUonE demonstrator, CMS-TK will be informed and consulted before the issues are publicly reported.

### 3.3. *Early results contributed to conferences:*

3.3.1. Before the “2S module performance paper” is published, MUonE contributions to conferences shall be exposed to CMS-TK Conference Committee and CMS-TK Editorial Board following the same procedures as for CMS-TK conference contributions, namely:

3.3.1.1. Draft slides are made available for comments to CMS-TK at least one week before the start of the conference.

3.3.1.2. A draft of any conference proceedings concerning 2S module performance is made available for comments to CMS-TK and has to be approved by the CMS-TK Editorial Board.

3.3.2. Conference proceedings shall contain a standard acknowledgment to CMS at the end of the document.

### **Outlook to a future MUonE experiment**

If, following the Test Run, MUonE is approved as a full-fledged CERN Experiment equipped with “2S” modules, it will need 250 “2S” modules: CMS-TK intends to provide these modules to MUonE.

The conditions at which modules will be provided shall be regulated by a formal Memorandum of Understanding to be issued in due time. It is expected that very similar conditions shall be agreed concerning material, labour and intellectual property and publications, whereas the financial conditions will depend on cost of components which will presumably be procured all with series production, rather than prototyping, orders and on details of the internal organization of CMS-TK for the construction of the modules.



**Approvals**

This MoA was approved by:

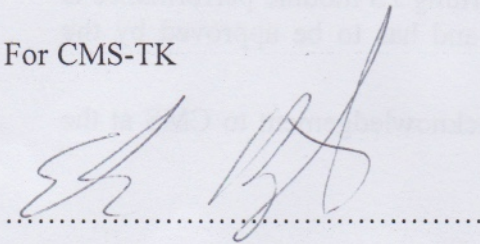
- The CMS-TK Upgrade Steering Group on 23 February 2021
- The MUonE Institution Board on 18 April 2021
- The CMS-TK Institution Board on 06 May 2021

This MoA is produced as two original documents, each one signed by representatives of the CMS-TK Group and the MUonE Collaboration.

Signed in Geneva, Switzerland

on 07 May 2021.....

For CMS-TK



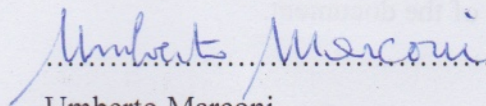
Erik Butz

CMS-TK Project Manager

Signed in Geneva, Switzerland

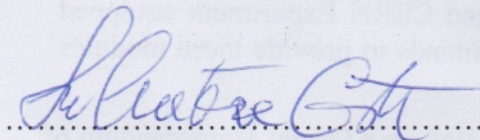
on 08/05/2021.....

For MUonE



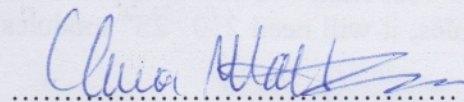
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Salvatore Costa

CMS-TK Institution Board Chair



Clara Matteuzzi

MUonE Institutional Board Chair