Response to LHCC Referee Questions

James L. Pinfold
For the MoEDAL-MAPP Collaboration

16th November 2021

Program

Referees Discussion with MoEDAL

Tuesday 16 Nov 2021, 02:20 → 15:30 Europe/Zurich

Videoconference

Meeting with MoEDAL Representatives — Join

14:00 → 14:20 **Organization, Resources, Operations and Other Points + Physics potential and studies** — 20m
Speaker: James Pinfold (University of Alberta (CA))

14:20 → 14:30 **Detector** — 10m
Speaker: Richard Soluk (University of Alberta (CA))

14:30 → 14:45 **The GEANT4 Simulation of the UA83, MAPP, MoEDAL Arena (SUMMA)** — 15m
Speaker: Matti Kalliokoski (Helsinki Institute of Physics (FI))

14:45 → 14:55 **The Cosmic Ray Background Simulation** — 10m
Speaker: Aditya Upreti (The University of Alabama)

14:55 → 15:05 **Physics Simulation of MAPP Response to Milli-Charged Particles** — 10m
Speaker: Michael Staelens

Introductory Remarks

CERN
Esplanade des Particules 1
P.O. Box
1211 Geneva 23 - Switzerland

EDMS NO.	REV.	VALIDITY
2617044	1.0	RELEASED

REFERENCE
LHC-X8MAPP-EC-0001

LHC

Date: 2021-11-11

Is beinENGINEERING CHANGE REQUEST

MoEDAL MAPP-mQP Detector in UA83

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

The MoEDAL collaboration proposes to install a new detector MAPP-mQP in the UA83 gallery at Point 8 of the LHC.
This document describes the changes required to accommodate the new project.

DOCUMENT PREPARED BY:	DOCUMENT CHECKED BY:	DOCUMENT APPROVED BY:
F. Butin BE-EA E. Dho EP-DI J. Devine EP-DI	M. Barberan, O. Beltramello, N. Bellegarde, C. Bernard, M. Bernardini, M. Brugger, G. Canale, N. Charitonidis, S. Cherault, A. Ciccotelli, J.-P. Corso, J. F. Fuchs, C. Gaignant, R. Garcia Alia, G. Girardot, A. Infantino, R. Jones, J. Kuczynska, H. Mainaud Durand, Y. Muttoni, T. Otto, L. Pereira, J. Pinfold, D. Ricci, F. Sanchez Galan, M. Solfaroli, R. Soluk, R. Steerenberg, K. Weiss, J. Wenninger	M. Lamont (on behalf of the LMC)

DOCUMENT SENT FOR INFORMATION TO:

C. Bertone, J. Blanc, G. Canale, M. Pirozzi, K. Buffet,
ATS groups' leaders

HSE
Occupational Health & Safety
and Environmental Protection Unit

›Safety Derogation Request Form

Date	Requested by	Dpt/Group
27 août 2021	MoEDAL- MAPP Experiment EP Safety Office	EP

ACCEPTED

DESCRIPTION OF THE REQUEST

Location / Project :
UA83

Regulation related to the derogation:
Plastic materials needed for the MoEDAL Detector are not conforming to CERN IS41, and specifically needed due to their physical properties.

Brief description of the Detector :
The MAPP detector is comprised of 400 x (10 cm x 10 cm x 75 cm) scintillator bars, wrapped in Tyvek and then black tape, each bar connected via a short light guide to a 3-inch PMT. The bars are arranged in 4 sections, each with 100 bars with overall sensitive area of 1m^2. The scintillator bars (NUVIA polystyrene based scintillator) in each section are held in a square array by three support grids made of High-Density Polyethylene (HDPE). A drawing of one of the basic HDPE support grids is shown in Figure 1. The grid separates the bars one from the other by 5m to 7 mm. The air fills the interstices between the scintillator bars.

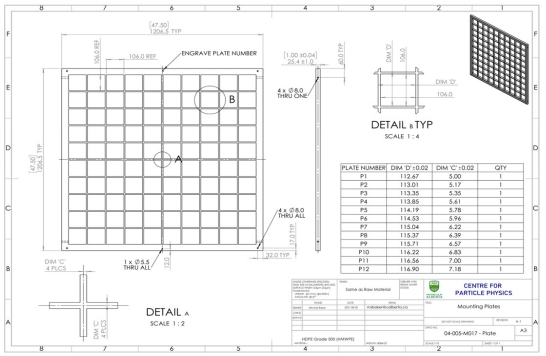


Figure 1: The drawing of one of 12 HDPE support grids of the MAPP-mQP detector

Organization (1)

Question: *The text is not clear on the actual EXSO responsibility: Sect 4.5 page 20: in the first bullet, the EXSO is given as "… the Spokesperson, Richard Soluk". Has Richard become the spokesperson? If not, who will be the EXSO: him or Jim? We really need clarity here.*

In this instance, the title "Spokesperson" has been replaced by that of "Technical Coordinator" in Version 2.1 of the TP.

Organization – Operating Team

MoEDAL

Comment: *The team is still very limited, and we remain concerned about the actual presence during running, providing necessary backups and prompt support in case of need. Some level of redundancy is desirable.*

We will maintain at least 2 people at CERN 24/7. With one person on call at all times.	There will be, in addition, on average 0.5 FTE MoEDAL-MAPP visitors, with safety training, able to take part in "on call" responsibility	The 24/7 CERN personnel responsibility is shared across the collaboration.	First year (2022) we expect the Alberta and Valencia groups to provide the CERN based personnel.

In the event an intervention is required during a TS a further 2-3 experts would travel to CERN to add to the CERN-based team.

Organization – Detector Control (1)

MoEDAL

Question: *You indicate that you plan to control the detector remotely (sec. 6) which is clearly fine, after all in a sense all LHC detectors are controlled remotely - but it does also sound as if you want to run "unsupervised", e.g. without 24/7 shifts actually monitoring the detector. Is this acceptable at CERN?*

The MAPP detector utilizes only scintillator-based detector technology that requires only LV supplies, frontend readout, and an only a FPGA-software based trigger. The power supplies are current limited and shut down automatically if currents exceed that limit

The safety quantities that need to be monitored and/or controlled are the LV supply currents, the trigger rates/ thresholds and the temperature sensors placed around on the outside of the MAPP flame shield.

MAPP is a simple single detector with no gas, HV cryogenics, magnet systems trigger, or complex subsystem/subdetector interdependencies.

Organization – Detector Control (2)

MoEDAL

Question: *You indicate that you plan to control the detector remotely (sec. 6) which is clearly fine, after all in a sense all LHC detectors are controlled remotely - but it does also sound as if you want to run "unsupervised", e.g. without 24/7 shifts actually monitoring the detector. Is this acceptable at CERN?*

The experiment will be *operated* 24/7 at CERN. By *operation* we mean monitoring the detector plus any required safety adjustment to the LV or shutdown of the power supplies. The CERN based operator will monitor the experiment as well as perform necessary safety operations such as turn off the power supplies and communicate with the CCC.

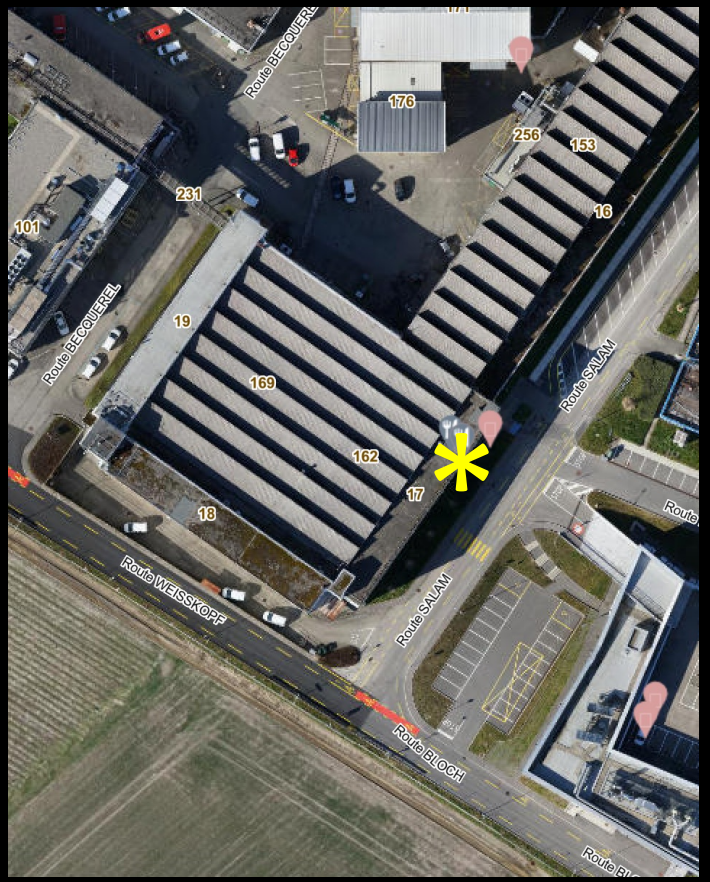
Alarm conditions will be also be mirrored to cell-phones held by the on call at CERN and the UofA centre as well as the Spokesperson and the Technical Coordinator (EXSO). Any *adjustment* to MAPP's operating parameters of the experiment, made for physics reasons will be performed remotely via computer from a control centre at the UofA

CERN requires that there is an on-call person 24/7 for small "stand alone" experiments

Organization – Control Room

Question: *It is not clear how you would operate the detector at CERN (or elsewhere): do you have an office that will serve as control room?*

We have an office at CERN – Bat. 17 R-007 – where the CERN operating centre will be housed.



MAPP can be controlled in a safe manner from this control room. The 24/7 operators have access to simple controls that allow them to turn of power and alert the CCC from their on call cell phones. The on-call operator and the off duty operator as well as the technical coordinator + Spokesperson also are connected to this system via cellphone

Operations – CCC Response

Question: *For the safety/monitoring alarms described on page 20, what is the proposed response from CCC in the case of an alarm condition?*

As the MAPP detector is on the "machine side" of IP8 Safety requirements mandate us to provide information on the safety status of MAPP to the CCC	The CCC will receive temperature sensor data, power supply readings and IR camera feed and an alarm condition.	If the risk is high we ask the CCC to check the IR camera feed and contact the MoEDAL-MAPP on call person.

HIGH

ELEVATED

NORMAL

OFF

ALARM LEVELS

Note the on-call, off duty on call, Technical Coordinator and Spokesperson are Informed if alarm levels reach "elevated"

Operations – RLSP

Question: *The resource loaded spreadsheet is not readable, can you provide separately the excel file, or enhance the quality of the image? Can you associate a table to Fig 22, with the details of the Resources, eg personnel for Team A etc.?*

We will arrange the spread sheet along the page in Version 2.1 of the TP

We will place a table explaining person power resources

Team	Members of team
Grad team A	M. Staelens, A. Salazar-Lobos
Grad team B	A. Shaa, M. Kelly
Staff team A	M de Montigny, P-P Ouimet
Staff team B	R. Soluk, Paul Davis, J. Pinfold
Elect techs	P. Davis, J. Chaulk
Machinists	D. Bizuk, J. Cameron, A. Vinagreiro

Operations – Liaison with LHCb

Question: *Sect 4.5 page 21: the second bullet introduces the "formal liaison with LHCb". What are the issues of potential relevance to LHCb? We had assumed that once in the UA83 gallery, no direct interaction with LHCb would emerge. Will you need to discuss and formalize these interactions, like it was done for MoEDAL?*

Although the UA83 location for LHCb means that there are no major interactions with LHCb we do share some of the same surface infrastructure.	Also, we are planning to move trapping detectors from MoEDAL on the LHC side of IP8 as part of our plan to monitor MoEDAL's trapping detector for the decays of trapped electrically charged particles.	However, the level of this interaction is on the level of information to the LHCb management. We will better define the level of this minor interaction in Version 2.1 of the TP.

MAPP MoU

Question: *We assume that a new MoU, or an appropriate addendum to the current MoU, may be necessary for MAPP. Has the discussion of this started with the collaboration Institutions and CERN's management?*

At the end of March 2021 we started a discussion with Helge Meinhard of the office of the Director of Research and Computing on the matter of an MoU for MoEDAL-MAPP. Helge gave us the following preliminary advice: *"In my opinion, detector upgrades including MAPP Phase-1 can be covered by changing the annexes to the MoU, which would avoid the rather lengthy signature cycle for a new MoU (or even multiple MoUs!) The Collaboration Board should approve these updated annexes, which should in turn refer to the LHCC and RB decisions. Joachim would report to the RB that the changes are sufficiently covered in annexes to the MoU, which addresses the RB's request…."*

Other Points – Trapping Detectors

Question: *It is said in the Conclusions that MAPP will be used to monitor possible decays from MoEDAL's Trapping Detector volumes. Will this be discussed in more detail a future addendum, or is this feature also up for review with this TP? Are there additional issues, eg mechanical or infrastructure-related, that must be considered?*

The monitoring of MoEDAL's trapping detectors will be addressed in a future addendum

Other Points – Outriggers

Question - We understand that the outriggers are just mentioned here for information, but they are not part of the TP and will be documented in a future addendum. However, for the sake of completeness: it is mentioned that the funding situation for the outrigger detectors should be clear by April 2022, would you be able to clarify whether there could be intermediate updates on the funding situation and also what would happen in case the funding doesn't arrive on time?

Our application was for a NSERC's Research Tools and Infrastructure (RTI) grant. The results of the grant will be known in April 2021 with no previous official notification.	The funding for the the MAPP detector awarded previously resulted from a successful RTI application	If this funding is not awarded we shall use Collaboration funds to acquire the PMTs.

Physics Backgrounds for mQPs

Response to Referee Questions

James Pinfold

For the MoEDAL Collaboration

Comparison of LHC's mQP Det.

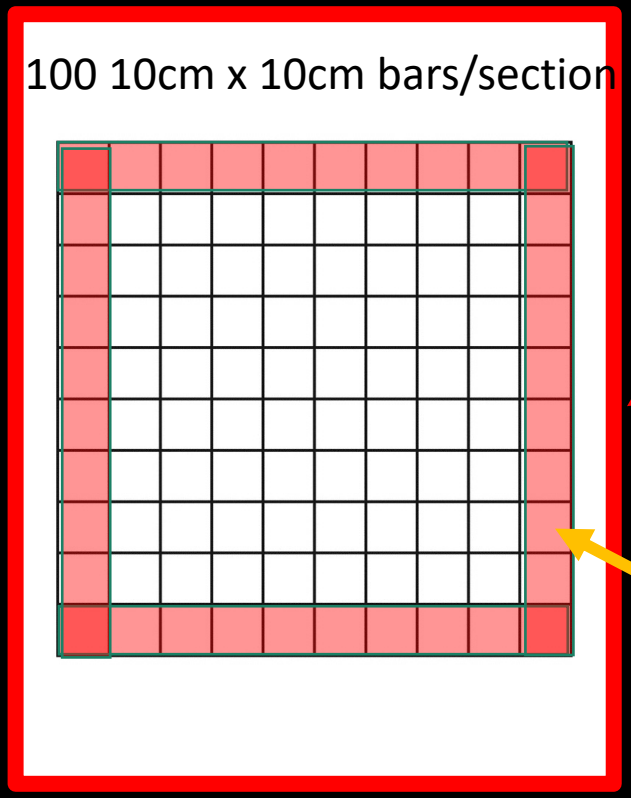
Item	MilliQan	MAPP-mQP
Distance from IP	33m	100m
Rock/cement shielding	17m	~35m
Angle to the beam	84 deg.	6.5 deg.
Overburden (rock)	73m	105m
Technology	Scintillator bars	Scintillator bars
#bars & Bar size	64 x (5cm x 5cm x 60cm)	400 x (10 cm x 10 cm x 75cm)
Layers of bars & PMTs	4 & 4	4 & 4
Sci panels tween layers	Front & Back	Front, back & between layers
Radiator layers	No	Yes
Hermetic VETO System	6 x 5cm thick panels each RO by 2PMTs	~167 x(25cm^2) tiles RO by SiPMs & 1" thick plates at each end & tween sections, R/O by 2PMTs

MAPP-mQP and milliQan cover complementary pseudo-rapidity regions

Physics Backgrounds & Studies(1)

- Question - *You mention beam-induced backgrounds, as well as cosmic rays. But here a somewhat more thorough analysis may be good, in particular on the possible impact of high-energy cosmic ray showers, which would result in multiple simultaneous particles. It is plausible that this can be rejected with very high efficiency, but it needs to be proven.*
  - MAPP has an active segmented (25 cm x 25cm) hermetic CR veto shield with efficiency of 99.9% or better with area top, bottom, side area of 19.2 m^2
  - MAPP is divided into 4 sections with VETO layers between each section and the two ends area of "vertical" vetos
  - MAPP is also quite deep at 105m (milliQan is 73m deep)
  - The milli-charged particle event candidate will have:
    - 4 contiguous bars will "mQP" type energy deposits and NO VETO hits anywhere
    - All VETO hits and "mQP candidate" energy deposits to be made in coincidence

Physics Backgrounds & Studies(2)



Hermetic segmented (25cm x 25 cm) VETO layer

Second VETO layer possible using outside 36 outer layer bars (10cm x 10cm each).

- The CR background will be studied during beam-on/off periods
- If necessary we can also deploy even more VETO power by using all outside bars (36 x 10 cm x 10cm) as a a VETO layer. This would result in a 36% reduction in acceptance.
- We are confident that CR shower backgrounds can be rejected with very high efficiency – however we shall back this up with detailed full-sim studies

Physics Backgrounds – Full-sim.

- Question- *What is the impact of backgrounds on the physics reach? Your plots still assume no background, although we had mentioned this as a shortcoming already quite a while ago. We need to see this with realistic background estimates, to be convinced that there will actually be a measurement.*
  - As you can see from M. Kalliokoski's talk we will have a GEANT-4 simulation that covers the complete UA83-MoEDAL-MAPP-Arena (SUMMA) ready soon.
    - This task was completed for the UGC1 gallery but we needed to move in June to a new location!
  - However, we are convinced we can make a mQP measurement*:*
    - The technology is completely standard and well understood and is also very similar in nature the other mQP detectors proposed and accepted
    - The main background to the mQP measurement is CR showers. We can deploy up to two very high efficiency VETO counter systems.
    - We are deeper (105m) and further (100m with 35m rock/concrete) from the IP and thus better protected from CR and SM backgrounds.
  - But, of course, full-sim studies are a top priority

Physics Backgrounds – other ?

- Question. *Sect 8.2: is there a way to tell whether a signal in the MAPP is due to a millicharged particle or to an EDM?*
  - Please see the talk of M. Staelens

- Question: *Fig 21: do the limits corresponding to the MAPP-O curve include the limits of MAPP-B, or are they the outriggers standalone performance? Looking at the region m<45 GeV, where the MAPP-O limit is worse than MAPP-B, suggests the latter. If so, why not combine the two?*
  - Please see the talk of M. Staelens

The TP Version-2.1

- All of the issues discussed above and mentioned in the questions and comments by the referees and LHCC committee members will be addressed in Version 2.1 of the TP.
- The new TP version will be available by Friday the 19th of November