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The MAPP-1 Outrigger Technical Proposal

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Abstract

This is the Technical Proposal for the Outrigger Detector (OD) for the MoEDAL Apparatus for Penetrating Particles (MAPP) being installed in UA83 for data taking during Run-3 and on. The OD is an auxiliary detector designed to greatly improve the acceptance of the Phase-1 MAPP detector (MAPP-1) for milli-charged particles with large fractional charges. The OD consists of four 6-m scintillator planks comprised of 60 cm x 30 cm x 5 cm scintillator slabs, deployed in a horizontal duct joining the UA83 tunnel to the beam tunnel in the vicinity of the MAPP-1 detector.

1 Introduction

A major part of the MoEDAL Collaboration's physics program for LHC's Run-3 and beyond involves the installation of a new detector called MAPP-1 (MoEDAL Apparatus for Penetrating Particles - Phase-1) [1, 2]. MAPP-1's purpose is to expand the physics reach of MoEDAL, which is focused on the detection of Highly Ionizing Particle (HIP) avatars of new physics, to include the search for mini-Charged Particles[1] (mCPs) with charges as low as one

[1]We use the term mini-charged rather than milli-charged to denote the lightly ionizing particle as it does not imply that the charge is $10^{-3}e$

thousandth the electron charge (e), as well as charged and neutral long-lived particle (LLP) messengers of new physics. Thus, the MoEDAL and MAPP-1 detectors operating together will be able to detect: HIPs, mCPs, and LLPs.

The MAPP-1 will include a sub-detector called ALabama Scintillator Outrigger (ALSO), or simply Outrigger Detector (OD). OD is an array of scintillator blocks arranged in 4 planks placed back-to-back in a duct (Duct-4) joining the UA83 tunnel and the beam-line tunnel, in the vicinity of MAPP-1, as shown in Fig. 1. Its purpose is to significantly enhance MAPP-1's acceptance for mCPs with an effective charge greater than $\sim 0.001e$. This Technical Proposal describes the details of the design, construction, and installation of the OD.

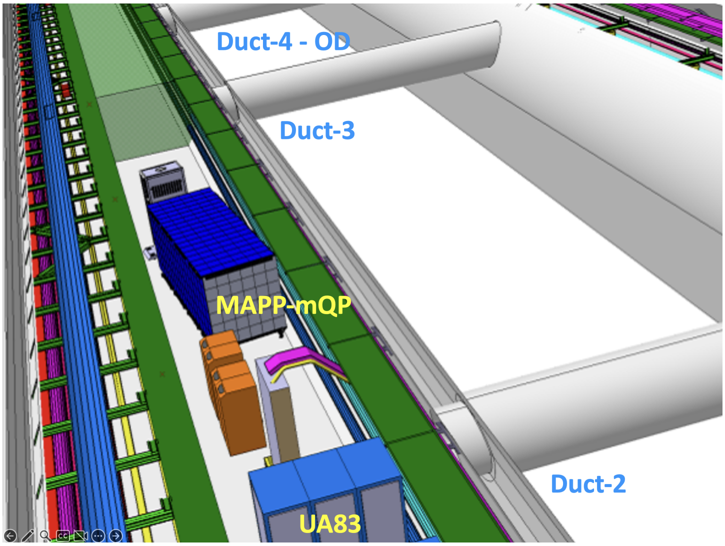
2 The Outrigger Detector for MAPP-1

MAPP-1 is currently being installed in UA83 tunnel some 100 m from the existing MoEDAL & LHCb detectors, to start data taking during LHC's Run-3. The MAPP-1 detector and its associated electronics rack has now been included in the overall LHC machine description as shown in Fig. 1. A drawing of the MAPP-1 detector is shown in Fig. 2. MAPP-1 is protected from Standard Model (SM) particles from interactions at IP8 by, on average, 45 m of rock, and from cosmic rays by an overburden of approximately 105 m of limestone.

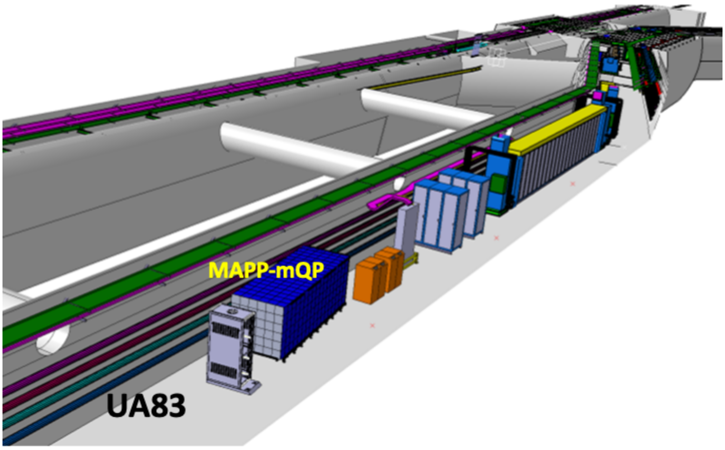
The MAPP Phase-1 detector is primarily designed to search for mCPs. It is made up of four collinear sections, with a sensitive cross-sectional area of roughly 1.0 m^2, each comprised of 100 (10 cm $\times$ 10 cm) plastic scintillator bars each 75 cm long. Each bar is read out by one low-noise 3-in PMT. The detector is arranged to point towards the IP. Thus, each through-going particle from the IP will encounter 3.0 m of scintillator and be registered by a coincidence of 4 PMTs. The 4-fold PMT coincidence essentially eliminates the background from "dark counts" in the PMTs. Additionally, the division of the detector into 4 bars virtually excludes all fake signal events arising from radiogenic backgrounds in the scintillator and PMTs. The MAPP-1 "bar" detector is hermetically enclosed in a veto layer consisting of 1.25 cm thick scintillator plates read out by embedded scintillating fibre loops with a size of 25 cm x 25 cm.

2.1 Placement of the Outrigger Detector

MoEDAL-MAPP has been given the green light to use Duct-4 for the OD on approval of the project. The numbering of Ducts starts from the end of UA83 nearest to IP8. Ducts 1, 2 and 3 are reserved for the machine group. The situation with Duct-5 is uncertain at this stage. The relative positions of Ducts 3, 4, and 5 are shown in Fig. 3. For Ducts 3, 4 & 5, the actual duct chosen does not make a significant difference to the sensitivity achieved with the OD.



(a)



(b)

Fig. 1: The deployment of the MAPP-1 detector in UA83. The proposed OD deployment in Duct-4 is indicated.

2.2 Outrigger Detector Technology

The basic scintillator unit of the OD is shown in Fig. 4. It is comprised of a slab of plastic scintillator (Bicron BC-408) of size 60 cm x 30 cm x 5 cm

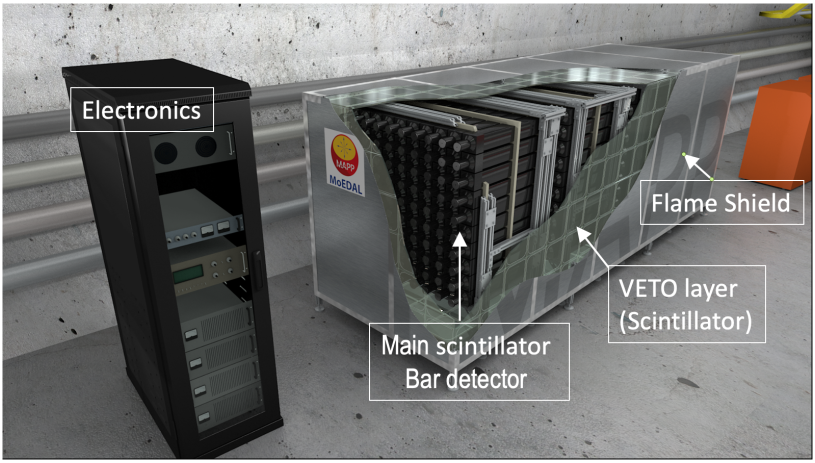


Fig. 2: A drawing of the MAPP detector showing the main elements of the MAPP detector.

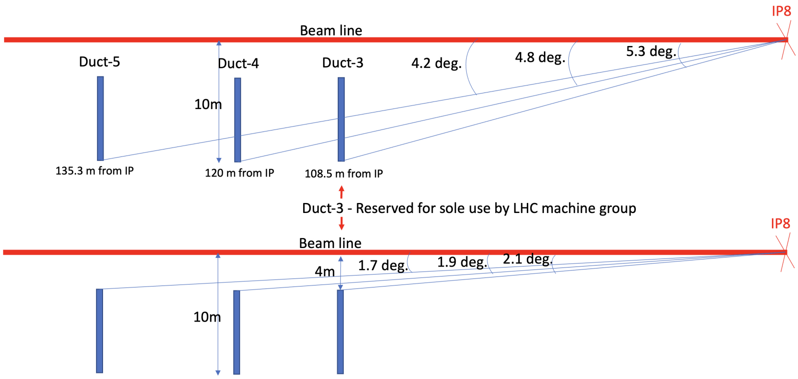


Fig. 3: The deployment of the OD adjacent to the MAPP-1 detector. Duct-3 has been reserved for machine use. Duct-4 is available to deploy the OD. The situation with Duct-5 is uncertain at this point.

readout by a single low-noise PMT. The PMTs utilized are 2-in Hamamatsu R2154-02s or 3.5-in HZC Photonics XP82B2FNBs. The units will be held on a rail at an angle of 45° so that the path length of particles from the IP in the scintillator is increased from 5 cm to approximately 7 cm. The units will also be overlapped back-to-back in "bricklayer" fashion to provide improved position resolution and also to accommodate the PMT housing which is slightly larger than the 5 cm thickness of the scintillator slabs.

Eight scintillator units are assembled on a rail in 4 layers to form a basic installation subunit, as shown in Fig. 5. The first three layers of a basic

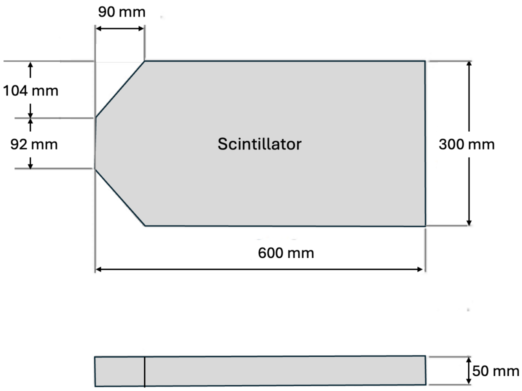


Fig. 4: The basic 5 cm-thick plastic scintillator (BC-408) slab from which the OD is comprised is readout by a single 2-in Hamamatsu R2154-02 PMT or a 3.5-in XP82B2FNB HZC Photonics PMT.

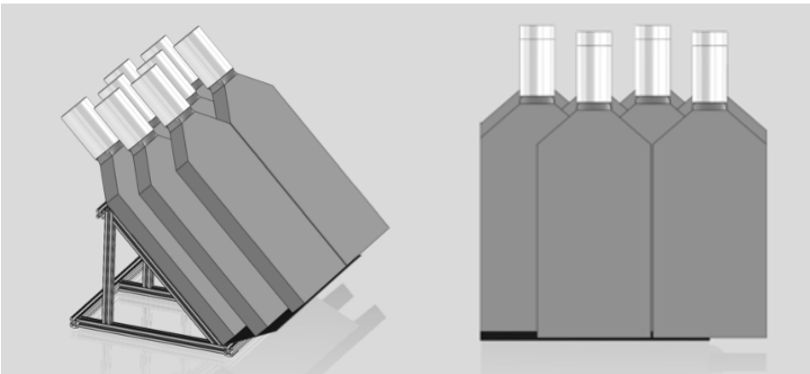


Fig. 5: The installation subunit of the outrigger detector.

installation subunit will be formed using dedicated scintillator slabs and 2-in Hamamatsu PMTs procured by the University of Alabama group. The fourth layer will consists of scintillator slabs cut out from EXO-200 scintillator veto panels loaned to MoEDAL by the Alabama group and 3.5-in HZC PMTs from another experiment donated to the University of Alberta. Fig. 6 shows a basic scintillator unit equipped with a 3.5-in PMT. This subdivision of eight scintillator units into one installation subunit is chosen to facilitate manual handling and allow for event selection based on signal coincidences between the layers. A total of ten such basic installation subunits will be installed in the Duct to form the OD, as shown in Fig. 7. This design approach is similar to that of a hodoscope array, a device often used in fixed-target particle detectors. An example definition of a gold-plated mCP candidate would be the coincidence of

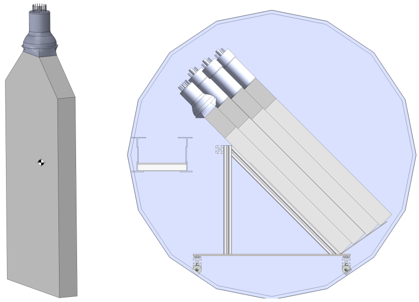


Fig. 6: The fourth layer of an installation subunit (right) will utilize 3.5-in HZC PMTs that will be attached to 60 cm x 30 cm x 5 cm scintillator slabs with the help of a light guide (left).

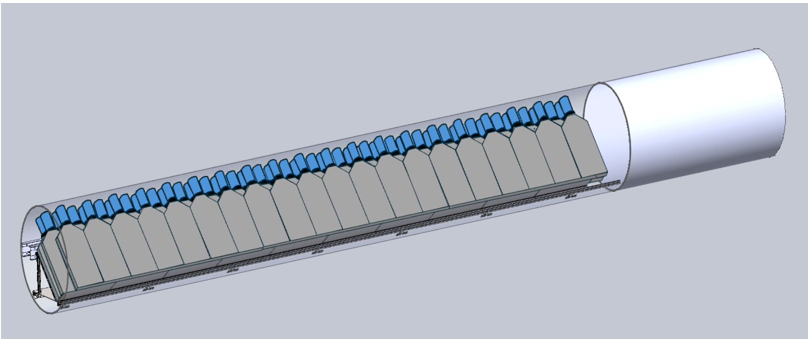


Fig. 7: The deployment of the Outrigger Detector in Duct-4. The solid piece at the end of the duct represents the shielding. The duct length is approximately 8 m.

all 4 layers where the scintillator blocks responding would be those consistent with a track passing through the OD.

Typically, a Minimum Ionizing Particle (MIP) will lose around 1 to 2 MeV/cm in a good plastic scintillator and generate on the order of 10K-20K photons per MeV lost. Consequently, this particle will deposit a comparatively large amount of light. Assuming a quantum efficiency of 25% for the detecting PMT and a 50% efficiency for the photon reaching the PMT, one expects on the order of 3.5 x 10^4 photoelectrons (PEs) in each scintillator slab through which the MIP passes. We have estimated that the light collection efficiency, including the loss due to photocathode efficiency, is $\sim$10%.

A relativistic charged particle ionizes roughly according to the square of its charge. A particle with around $10^{-2}e$ would give us on the order of a few PEs in each slab. Thus, using this very approximate calculation the OD is limited to the measurement of mCPs with a charge of $10^{-2}e$ and above. However, several other factors need to be taken in account, including a detailed knowledge of the photon detection efficiency of each bar, as well differences in the scintillation light output for different particles depending on charge and velocity. Another important effect is the Landau-Vavilov fluctuations [4] of the energy loss. Indeed, at the limit of the detector's sensitivity, the most probable energy loss instead of the average energy loss needs to be used for a more accurate estimate.

A detailed simulation aimed to more accurately calculate sensitivity of the experiment has been created and is under test. It is named SUMMA (Simulation of the UA83, MoEDAL, MAPP-1 Arena). This simulation is vital in understanding the response of the detectors at the limits of their sensitivity.

2.3 HV, Readout, DAQ, and Trigger

The PMTs utilized in the readout of MAPP-1 and its OD will have a resistive HV divider with an impedance of 4 MΩ, a maximum voltage of 2000 V and a current of 500 μA. The photocathode will be at ground potential with positive high voltage applied to the anode. The signal will be capacitively coupled to the cable.

The power supply will consist of a boost converter to convert from 48 Vdc to 250 V using a coupled inductor to reduce the maximum voltage seen by the controller. Several stages of a Cockcroft-Walton multiplier will then increase this up to 2000 V. The boost converter will be controlled by a small inexpensive 6-pin microcontroller which can accept serial data and synchronization pulses from the DAQ The Front end is connected to the DAQ via an MCX connector. Power, signal and control will all be delivered via the same cable to reduce cabling costs. In this way we avoid HV cables and connectors as well as the related safety concerns

The technology for HV, readout, DAQ, calibration, and trigger used for the main MAPP-1 detector will also be used for the OD. However, the Outrigger will have its own software trigger and operate autonomously, although the data will use the same DAQ computers and data-path out of the cavern.

A block diagram of the electronic readout and powering scheme for the MAPP-1 and OD is shown in Fig. 8.

Each DAQ board will consist of 32 identical channels. The DAQ will connect to the front end via an MCX connector. A bias tee will couple the 48 V DC supply to the signal line. Control signals for the high voltage power supply will also be coupled capacitively to the signal line. The amplifier chain will include a programmable gain amplifier to allow tuning of the overall system gain, minimal shaping, and an anti-alias filter. The ADC will consist of a Texas Instruments ADS4249 Dual-Channel, 14-Bit, 250-MSPS Ultralow-Power ADC readout to an Intel (formally Altera) Cyclone IV FPGA via LVDS.

The FPGA will perform discrimination, coincidence and peak detection of the incoming signals, with inter-FPGA communication via backplane B-LVDS. Events that pass both the software trigger and the veto will be passed for storage via Ethernet to the PC(s). The system will run synchronously to the LHC (bunch crossing) clock. The orbit clock will also be used to veto background

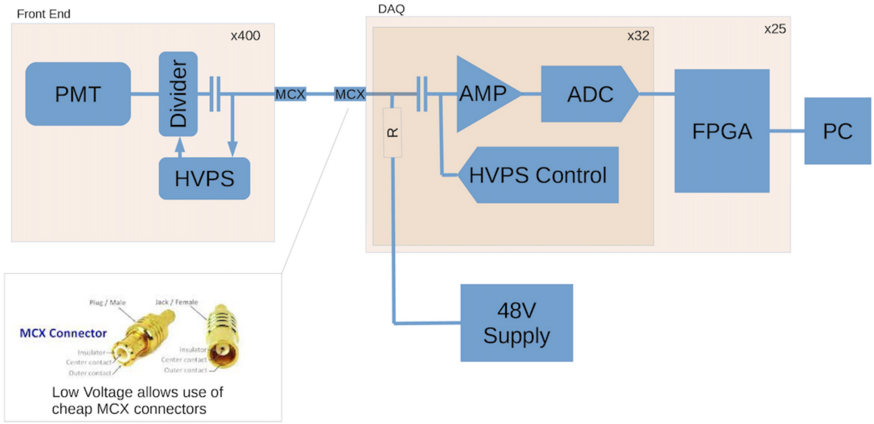


Fig. 8: A block diagram showing the basic electronics readout structure for the MAPP-1 and OD.

events from non-colliding bunches and to synchronize health keeping events and switching regulator noise to the abort gap.

Normally, the data will be transferred via 1 Gbit/s Ethernet link to an external computer. There will also be a computer in UA83 that will store data if there is a failure in the Ethernet connection. The data will be sent via the onsite storage via the internet to analysis sites in Canada, UK, USA, Spain, and Italy. The 19 readout boards will be housed directly underneath the MAPP-1 detector in the UA83 tunnel.

The data rate is expected to be on average less than 1 Hz from each of the 400 bars of the MAPP-1 detector with around another 200 channels from the veto detectors and radiator at maximum. There are 80 extra channels contributed by the OD, corresponding to the 80 scintillator units comprising the detector.

Conservatively assuming a rate of, on average, 1 Hz for each of the 680 channels involved, with 200 bits per channel (or PMT pulse) being read out, the total data rate is around 140 Kbits/sec. At this rate, our system can read out 4 million channels/s, i.e., about 5900 times more capacity than needed. The data in the front-end readout electronics is pipe-lined, so that large upward fluctuations in the data rate can be handled. Thus, these boards could be used for high luminosity LHC.

There will be several software triggers carried out by FPGAs housed in the readout system. The trigger philosophy is to widen the trigger as much as possible. Additionally, we aim to take minimum bias events at the rate of approximately 5% of the total data rate. Nevertheless, we expect the amount of data read out will be somewhat less than the maximum mentioned above. Further, higher-level "triggers" will be applied offline to the raw data. We chose to adopt this approach rather than reading out the complete detector at each beam crossing since the flow of data through the various triggers enables us to monitor the physics response of our detector online.

An example of an important “software” trigger for MAPP-1 and the OD is the through-going muon trigger. In the MAPP-1 case, a basic muon trigger is formed from a coincidence of 4 contiguous scintillator sections. In the case of the OD, the muon trigger is formed by a “hit” in each of the 4 scintillator layers where those hits are consistent with forming a collinear track. The trigger efficiency is estimated to be very near 100%.

2.4 The Outrigger Detector Calibration System

The OD will be calibrated with an array of blue LEDs, corresponding to the wavelength of maximum emission by the scintillator slabs and peak sensitivity of the PMTs forming the detector. Each scintillator slab is equipped with an LED that is pulsed in such a way as to mimic the light deposited by particles with varying fractional charge, down to the level where only single photoelectrons are being detected by the PMTs. The LED pulser system is calibrated with respect to the flux of muons through the OD.

3 Cosmic, Beam, and Interaction Induced Backgrounds in the MAPP-1 Region

A MAPP-1 *Prototype* was deployed in 2018 in the UGC1 gallery. Its main purpose was to enable us to estimate the data rate we would expect during Run-3. The prototype was comprised of nine 10 cm x 10 cm x 120 cm scintillator bars deployed in a *horizontal* configuration in the UGC1 gallery. Each bar was read out at both ends by a PMT. A hit on a scintillator bar was counted if the PMTs at each end of the bar registered a coincident signal above the threshold. We observed that with beam-off each bar was hit at around a rate $\sim$0.05 Hz. This rate was largely due to cosmic rays, despite the roughly 100 m rock overburden. This level of cosmic background was consistent with our GEANT-4 based simulations.

The disposition of the UGC1 gallery with respect to the UA83 tunnel is shown in Fig. 9. Although the UGC1 gallery was utilized for the MAPP-1 *Prototype*, it was determined by the LHC Machine Group that the UGC1 gallery would need to be upgraded to allow it to become an experimental area. The work to do this could not be scheduled in time for the deployment of the full MAPP-1 detector at Run-3. Hence, a new location was found for MAPP-1, in the UA83 tunnel. We expect this level of cosmic ray activity in the UA83 tunnel to be the same as in UGC1 gallery as it lies at approximately the same depth beneath the same rock overburden.

When the beam was turned on, we observed the rate in the MAPP-1 *Prototype* bars placed in UGC1 increased by a factor of 4 to 5. To study beam-induced backgrounds more fully, Francesco Cerutti and Alessia Ciccotelli of the Beam-Machine Interaction section of the CERN Engineering Department have performed a study of the beam-induced backgrounds in the UA83 tunnel

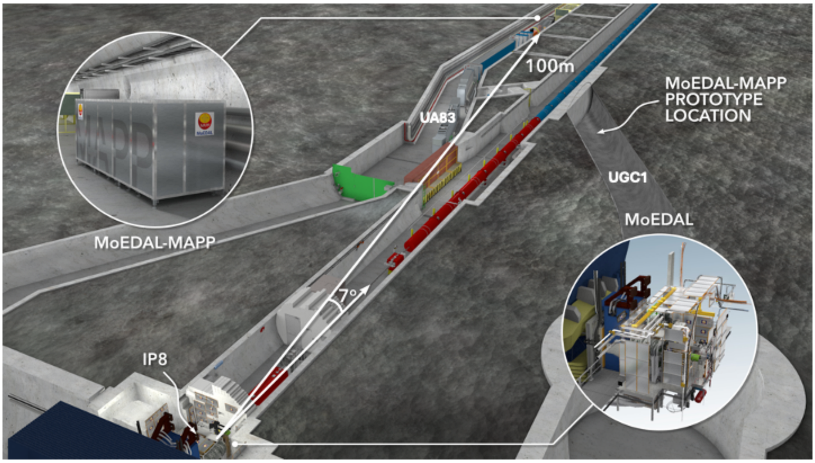


Fig. 9: The disposition of the MoEDAL-MAPP facility underground.

and the UGC1 gallery using the FLUKA Monte Carlo program, assuming an annual luminosity of 10 fb^{-1} [5]. According to the FLUKA studies, the beam-induced backgrounds in the MAPP-1 detector in UA83 should be considerably less than expected in UGC1, except in the regions immediately adjacent to where Ducts connect UA83 with the beam tunnel.

A critical issue is the effect of the radiation on the detector and on its electronic readout system. A key variable here is the dose which is shown in Fig. 10. As can be seen from the figure, the dose received by the MAPP-1

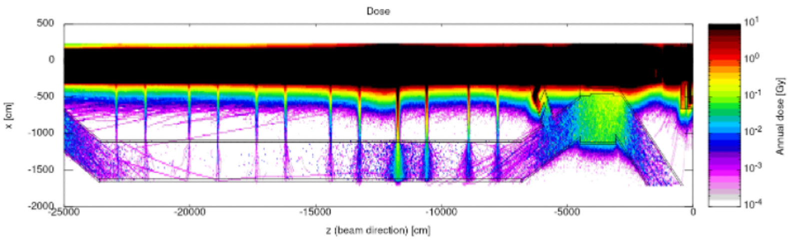


Fig. 10: The dose rate in the vicinity of MAPP-1.

detector in its new position in the UA83 tunnel is estimated to be below 1 mGy/year, a factor of 300 less than its initially proposed deployment in the UGC1 gallery.

Fig. 11 shows a map of the muon fluence component of beam-induced backgrounds expected at the UA83 ($< 10^6$ cm^{-2}), compared to the UGC1 ($\sim 3 \times 10^8$ cm^{-2}) locations of the MAPP-1 detector. We see a better than a 300 times reduction of the muon flux in the UA83 location compared to the UGC1 position.

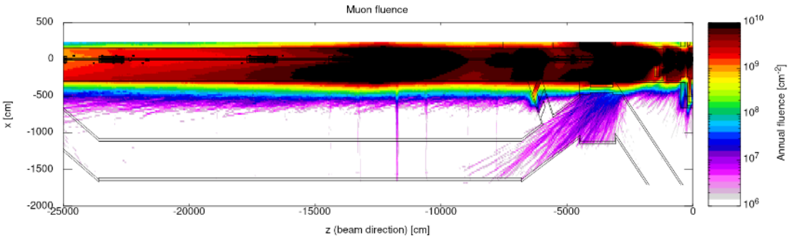


Fig. 11: The muon fluence in the vicinity of MAPP-1.

Likewise, the neutron flux (5×10^7 /year) and photon flux (10^8 cm^{-2}/year) at the position of the MAPP-1 detector in UA83 show at least a few hundred times reduction over MAPP-1's previously proposed position in the UGC1 gallery, as shown in Fig. 12 and Fig 13, respectively.

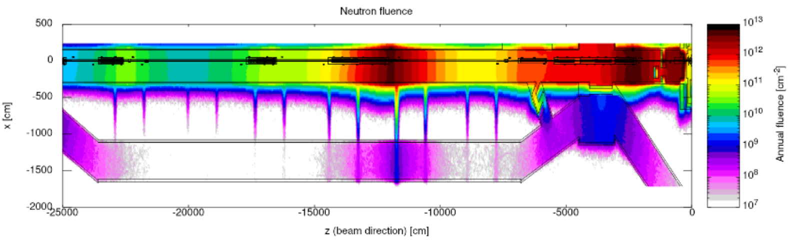


Fig. 12: The neutron fluence in the vicinity of MAPP-1.

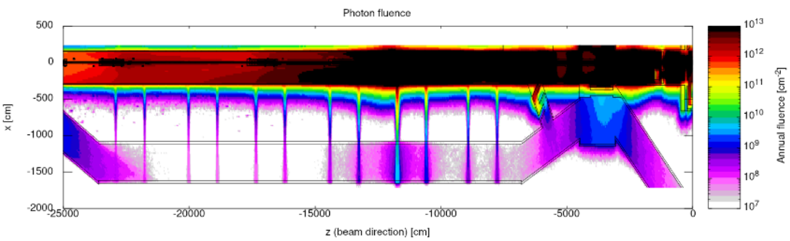


Fig. 13: The photon fluence in the vicinity of MAPP-1.

3.1 Beam Backgrounds in the Vicinity of the Outrigger

In the region by the mouth of the Ducts in the UA83 tunnel, the beam-induced backgrounds rise substantially, since radiation can travel down the

Ducts unimpeded. Thus, before we install the OD in Duct-4, we will install shielding in the beam-tunnel side of the Duct.

We are required by the Machine Group to use iron pieces rather than poured concrete as shielding. We worked with the Beam-Machine Interaction section of the CERN Engineering Department to assess the effect of the shielding using FLUKA simulations. In this estimate, we established that 1 m of continuous iron shielding was equivalent to 2 m of poured (continuous) concrete. The effect of Total Ionizing Dose (TID) of 1 m of continuous iron shielding is shown in Fig. 14. As can be seen from the figure, the 1 m of iron

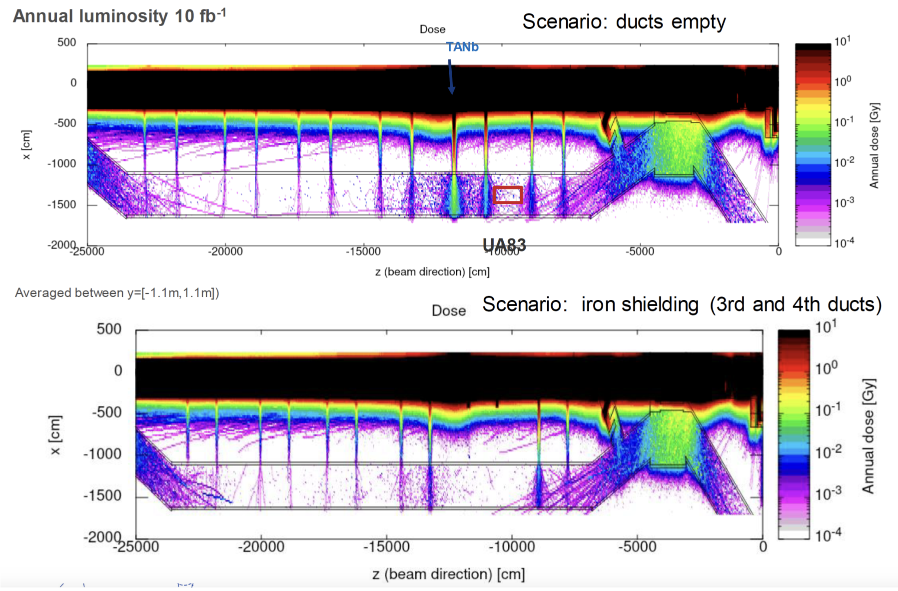


Fig. 14: The map of TID in the MAPP-1 region of UA83. Two ducts assumed closed in the simulation, while only Duct-4 will be closed in the end.

shielding substantially reduced the passage of radiation through Ducts 3 and 4, where the 1 m of continuous iron shielding was deployed. This is despite the presence of TANb nearly adjacent to the mouth of Duct-4. Fig. 15 shows the effect of the shielding on the Thermal Neutron Flux (TNF). We note that while two ducts were assumed closed in the simulation, only Duct-4 will be closed in the end.

The effect of the shielding on the fluences of High Energy Hadrons (HEH), thermal neutrons, Dose, photons and muons is shown in Fig. 16. In the plots depicted, the 1 m of continuous iron shielding is compared with 2 m of poured concrete.

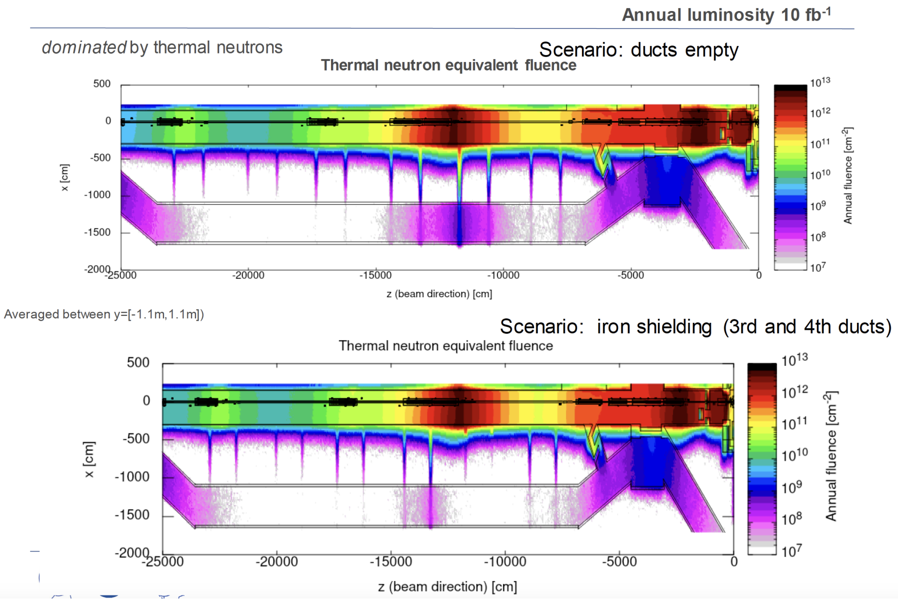


Fig. 15: The map of the TNF in the MAPP-1 region of UA83. Two ducts assumed closed in the simulation, while only Duct-4 will be closed in the end.

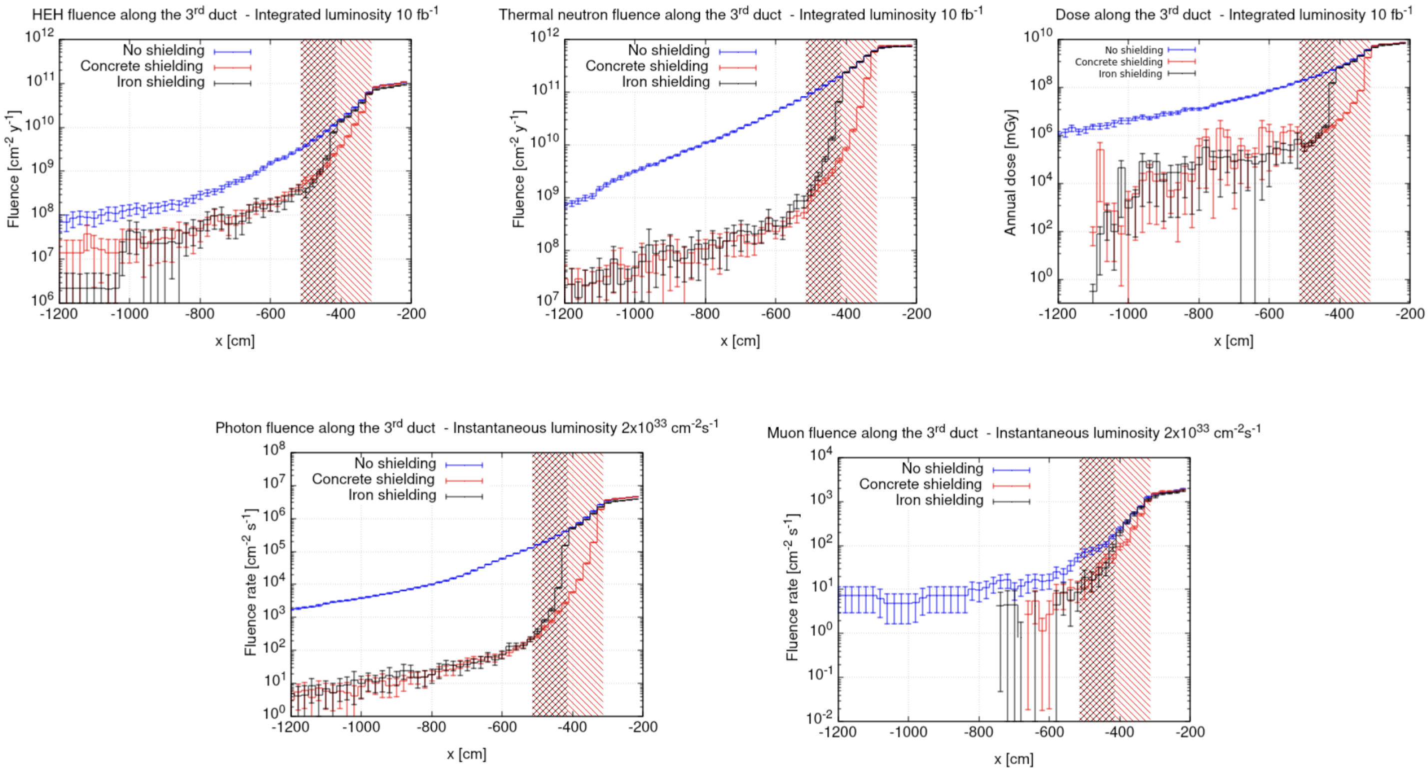


Fig. 16: The effects of 1 m of continuous iron shielding and 2 m of poured concrete shielding on beam backgrounds in Ducts 3 & 4 in the MAPP-1 region.

3.2 Cosmic and Interaction Backgrounds in the Vicinity of the Outrigger Detector

The MAPP-1 Outrigger Detector, like its counterpart the milliQan Slab Detector, has no dedicated Veto. As shown in Fig. 5, the OD is comprised of slabs overlapped in "brick-layer fashion", which is also shown more clearly in Fig. 17. It can be seen from this figure that it is virtually impossible for an impinging charged particle from IP8 to "skim" the edges of the 4 blocks to satisfy the mCP trigger since skimming one block would entail hitting the following overlapped block head-on. In addition, the OD is embedded in the 8 m thick concrete wall separating the UA83 and Beam tunnels. Thus, a particle coming from the direction of IP8 would need to travel approximately 80 m in concrete to impinge on the OD, as opposed to around 40 m in concrete to enter the front face of MAPP-1. Initial estimates indicate that the incidence flux of particles per m^2 of the OD would be around 10 times less than that on MAPP-1.

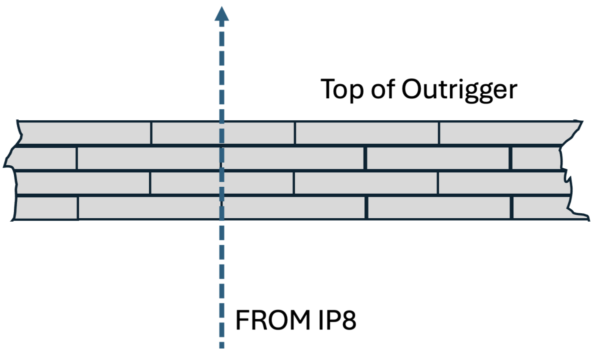


Fig. 17: Top view of the OD scintillator slabs when installed in the Duct.

Considering the background from cosmic rays, the MAPP-1 and OD enjoy a roughly 30 m greater overburden than does milliQan. The verticality of the cosmic ray background also makes it difficult to achieve a 4-fold coincidence of the Outrigger scintillator blocks. This coincidence can be achieved if the cosmic ray particles come in at an angle. But in this case, the cosmic rays would need to traverse an effective overburden greater than 105 m. Furthermore, to mimic an incident mCP from IP8, the cosmic ray particle would need to skim the edges of four blocks. Again, the overlapping configuration of the blocks makes this extremely difficult, if not impossible. Finally, we plan to utilize the Veto system of the MAPP-1 detector to also Veto the OD in the event of a large coincident "shower" of cosmic ray particles hitting the MAPP-1 detector.

4 Construction and Installation of the Outrigger Detector and Extra Shielding

The University of Alabama (Alabama) has procured enough 2-in Hamamatsu PMTs and Luxium Solutions BC-408 scintillator slabs cut to the necessary size (Fig. 4) to instrument 60 (+2 spares) scintillator units of the OD. The slabs have already been wrapped, with all the PMTs and calibration LEDs glued in. Fig. 18 shows the work on the OD detectors at Alabama. At this point they only lack the PMT bases, which are expected to be manufactured as soon as the board design is available. Fig. 19 shows the OD detectors prepared for

Fig. 18: Work on OD scintillation units at the University of Alabama. As of end of August, all 60 slabs has been wrapped, and the calibration LEDs have been glued in. Roughly half of the slabs have the PMTs glued in. From left to right: Alabama students U. Ullah, B. Davis, A. Upreti.

shipment to CERN.

Alabama has additionally loaned enough large plastic scintillator panels to the University of Alberta (Albeta) group to instrument the remaining 20 scintillator units using the HZC PMTs donated to Alberta. However, the large plastic scintillator panels, which were previously utilized by the EXO-200 experiment, first need to be cut to the necessary size. A main element of this effort is the installation at Alberta of a new machine tool to fabricate the scintillator slabs. A plan drawing of the machine, the PERFORMA ATC PLUS router and cutter manufactured by PRECIX, featuring a 4 ft x 8 ft bed, is shown in Fig. 20. This machine is now installed in the machine shop of the Physics Department at Alberta and is expected to become operational by the end of November 2024.

Fig. 19: OD scintillation units at the University of Alabama, ready to be shipped to CERN.

In the above-mentioned simulation of the protection afforded by iron and concrete shielding against beam backgrounds, only continuous shielding was considered. As the Machine Group has ruled out the possibility of poured concrete we are limited to iron shielding. The iron shielding will be inserted into the duct in pieces. These pieces will be of different lateral sizes to pack the circular space of the duct as efficiently as practically possible. A diagram showing the packing scheme is shown in Fig. 21. Smaller-sized bar and thick wire will be used to fill holes wherever possible at the time of installation.

Although the shielding packing scheme is efficient, it will be impossible to eradicate narrow holes between the shielding pieces. It is envisaged that the main background penetrating along the narrow channels between the iron shielding would be neutrons. To further reduce this background we will install 8 x 1-in (20 cm) layers of borated polyethylene [6] cut to fit the circular duct. Fast neutrons are effectively thermalized by hydrogen. The shielding we will employ has an inherently high concentration of hydrogen, over 13% of volume. Thermalized neutrons are then shielded by boron, which has a large capture cross section, roughly two thousand times larger than that of hydrogen. Additionally, the gamma rays released during boron captures have roughly five times smaller energy when during hydrogen capture, so may not require a separate absorber. The effectiveness of the shielding will be studied in the run with a view to corrective action if necessary.

Another minor consideration is the potential residual magnetization of the iron shielding. To minimize potential impact on the OD's PMTs, a 0.33-mm mu-metal sheet is foreseen to be installed on the inner side of the shield.

The installation of this shielding was the topic of an Engineering Change Request: *MAPP-1 Outrigger detector installation in UA83-LHC tunnel link*

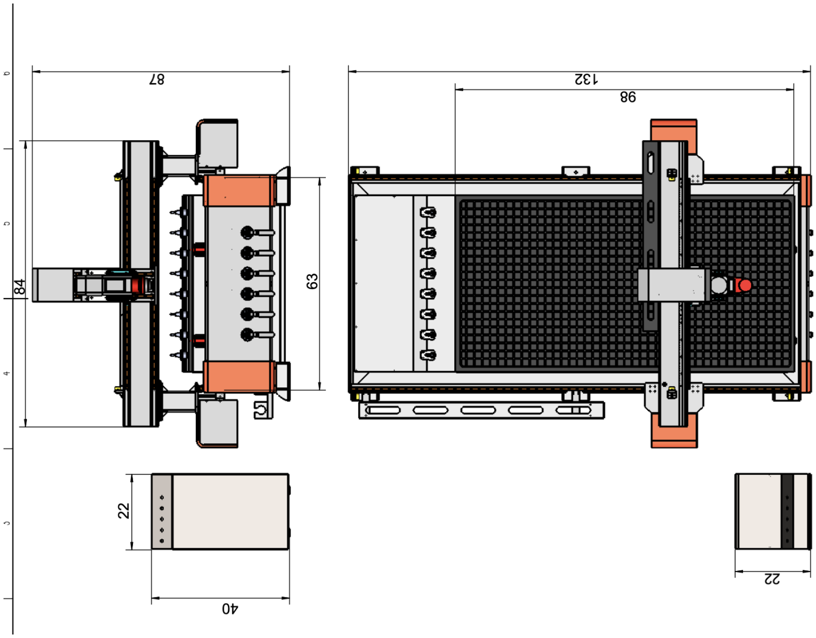


Fig. 20: A plan view of the PERFORMA ATC PLUS router and cutter manufactured by PRECIX, featuring a 4 ft x 8 ft bed.

ducts at LHC Pt 8, submitted on the 19^{th} of October 2023. That ECR, approved on November 1st, 2023, is included in Appendix (A) [7]. In the installation plan envisaged in that document, the installation of the iron shielding would have gone ahead in mid-January 2024. To enable ease of installation the shielding would be inserted from the beam-line tunnel side. The support rails and cable trays internal to the duct would be placed just before the shielding installation.

Approval for the installation of the MAPP-1 OD was not possible at the December 2023 LHCC/CRB. If approval is obtained in the Fall of 2024, then the installation would take place in the 2024 EYETS. The first elements to be installed in Duct-4 will be the support rails, the cable trays, and the iron shielding. Once this has been completed, the scintillator units would be assembled into the installation subunits shown in Fig. 5. A standard lifting table will be used to raise each subunit to the correct height to be slid onto the mounting rail. These subunits would then be inserted along the rails into the Duct.

Below is an outline of the tentative installation schedule for the support rails, cable tray, and shielding within Duct-4. The tasks expected to take a few hours are conservatively rounded off to one day.

- Scaffolding will be installed on the LHC side (1 d),
- The team in charge of removing the air tightness plug on LHC side and the internal existing structure will work (1 d),

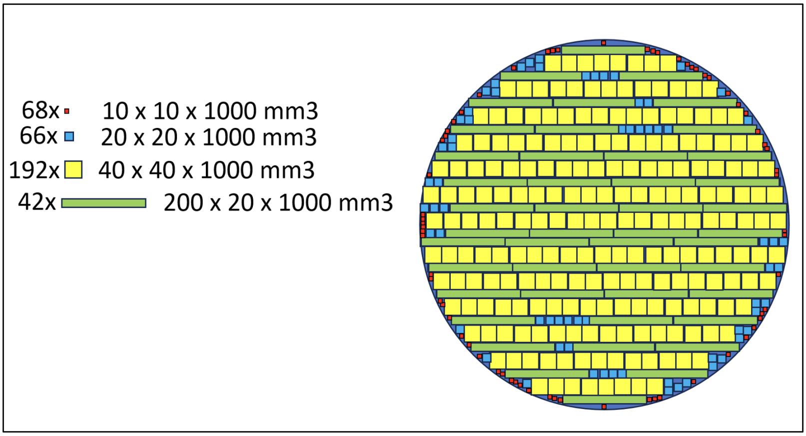


Fig. 21: The packing scheme for the 1 m long iron elements constituting the shielding for the Outrigger detector in Duct-4.

- The cable tray will be removed (2 d),
- The scan of the inside of the duct will take place (1 d),
- Duct-4 and region will be available for installation of our support rails and cable tray, internal to Duct-4 (4 d),
- The iron shielding will be laid (3 d),
- The air tightness plug will be re-installed (1 d),
- The scaffolding will be removed (1 d).

Following the above, the detector subunits can be inserted along the rail inside the duct, fully cabled. This should be accomplished in a few days, leaving about a week before the end of EYETS access to the tunnels for the commissioning of the detectors. A total of 10 subunits (roughly 20 blocks wide) would be installed in Duct-4. The total area of plastic seen by particles from the IP as they impinge on Duct-4 is 20 x [30 x 60 x sin(45°)] = 2.7 m^2, compared to ∼1 m^2 for the MAPP-1 detector.

The readout of the OD PMTs, as well as the calibration system, will be cabled into the main electronics readout rack of MAPP-1 detector as the OD subunits are installed. The electronics readout and calibration system is functionally the same as that of MAPP-1 detector. The cables carrying LV power and signals to and from the PMTs are housed in the cable rack installed along the length of the Duct behind the scintillator blocks.

A Gantt chart showing the tentative installation schedule is provided in Fig. 22. The delivery of the scintillator blocks and PMTs has already been completed, so is not included in the chart.

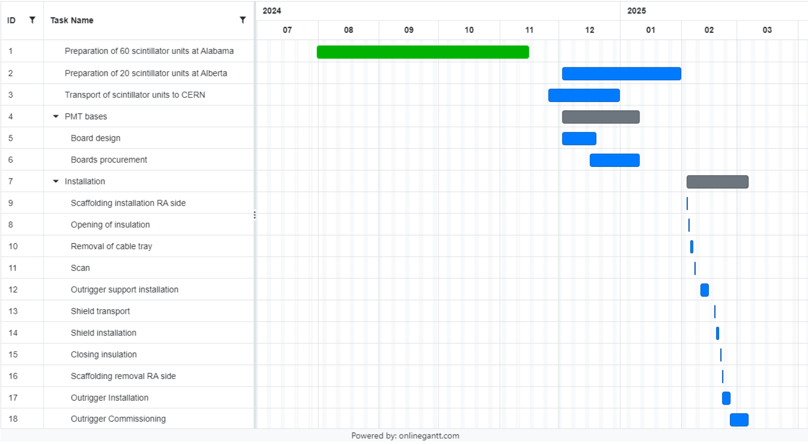


Fig. 22: Schedule for the construction and installation of OD elements.

5 Safety Matters

The safety issues considered below arise from sources related to the UA83 tunnel, detector itself and its operations. The approved Safety Derogation Request for the MAPP-1 detector which uses all the same detector elements as its Outrigger Detector is shown in Appendix (B) [8].

5.1 UA83 Tunnel and Detector Safety Issues

The UA83 tunnel is a full part of the LHC machine infrastructure with access via the PM85 lift directly to the floor of UA83. It is equipped with interlock access, smoke detector, fire alarms and forced ventilation.

The total mass of plastic scintillator used to construct the OD is around 700 kg. The safety sheets for polyvinyltoluene plastic are included in Appendix (C). The OD will be situated within Duct-4 that passes through the 8 m thick concrete wall that separates the UA83 tunnel and the beam-line tunnel. Shielding is placed on the beamline tunnel side of Duct-4 to reduce beam backgrounds. The remaining 7 m of the Duct will be used to house the OD. Thus, the detectors are surrounded by metres of concrete, except for the opening into the UA83 tunnel. An aluminium flame shield will be placed across the mouth of the opening to completely isolate the detectors.

The detector electronics rack and MAPP-1 detector will be monitored by an IR + Visible light digital camera placed in the vicinity of MAPP-1 in the UA83 tunnel. The OD, which do not obtrude into the UA83 tunnel itself, will be equipped with smoke and temperature detectors that are monitored in the same way as the MAPP-1 temperature sensors.

5.1.1 Safety Issues Related to the Readout Electronics & HV

The readout electronics and power supplies are isolated and deployed up to 10 to 20 m from the OD in the electronics racks servicing the MAPP-1 detector. There are no HV cables or HV connectors as there is a "Cockcroft-Walton" type converter in the base of each PMT that converts LV power to HV power for the PMT. The power supplies are low voltage (24 V), are current and temperature limited (turn off when current or temperature goes out of a pre-determined range), and provide an alarm signal when current or voltage moves out of some predefined operating window. The MAPP-1 and OD electronics consume less than 2 kW of power.

All cabling is halogen-free according to the provisions in IS23[2]. The only other heat source in the UA83 gallery arises from the MAPP-1 detector electronics and amounts to less than 2 kW.

5.2 Safety Issues Relating to Detector Installation

The OD is designed to be installed *in situ* from pieces weighing a maximum of approximately 20 kg each, although most elements will weigh substantially less. Thus, the whole OD can be taken underground using the machine side elevator at IP8. We anticipate that a maximum of four people will need to be present in the UA83 gallery for the installation. The installation personnel will be equipped with all the required safety gear and operate according to the safety rules and guidelines described in the safety courses each team member will have taken and passed.

5.3 Safety Monitoring After Detector Installation

The MAPP-1 Outrigger Detector is read out over Ethernet through the same pathways as the MAPP-1 detector. It does not require a team to operate it during data taking. However, the detector must be monitored to ensure safe operation at all times. The safety systems that will be installed to ensure that the detector is operating safely are as follows:

- The power supplies are current limited. In addition, alarm conditions are defined that signal non-standard operating characteristics. The power supplies output and alarm conditions are monitored remotely with a feed supplied to the CERN Control Centre (CCC);
- Three temperature probes will be placed at the end, middle, and entrance of the Duct-4 housing the OD. Alarm conditions are defined that signal if any monitored temperature moves above normal ambient temperature in the UA83 tunnel. The temperature probe outputs and alarm conditions are monitored remotely with a feed supplied to the CCC.
- An IR camera will be installed on site to monitor the whole MAPP-1 detector region. Again, the feed from the camera will be supplied to the CCC.

[2] https://edms.cern.ch/document/335745/4

5.4 MoEDAL-MAPP Safety Organization

The MoEDAL-MAPP safety organization at CERN will be established before installation. It will consist of:

- An Experimental Safety Officer (EXSO, formerly GLIMOS) and two Deputies (DEXSO) as the point of contact for all experimental safety issues and communication with the EP Safety Office. The EXSO for MoEDAL for installation and the first year of running, will be the Technical Coordinator, Richard Soluk. The DEXSO are Subash Behera and Jack Lindon, with the former DEXSO currently stationed at CERN throughout the year;
- Both the EXSO and the MoEDAL-MAPP Spokesperson will be available for urgent safety interventions required during the detector installation;
- All the activities of installation will be declared via IMPACT requests [9] and analyzed via the usual work package analysis and VIC (Visite Inspection Commune) procedures;
- The MoEDAL-MAPP safety files will be created on EP safety office EDMS and shared with the LHCb LEXGLIMOS.

5.5 Organization of Construction, Installation and Running of the Detector

The two bulleted lists below describe the basic organization of the construction and installation of the Phase-1 MAPP-1 detector:

- **Project Managers**:
  - **MAPP-1 & Outrigger Coordinator-2** - Igor Ostrovskiy;
  - **MAPP-1 & Outrigger Coordinator-1** - Richard Soluk;
  - **Chief engineer** - Mitchel Baker;
  - **Chief electronics engineer + Trigger and DAQ coordinator** - Paul Davis;
  - **CERN based administrator** - Veronique Wedlake;
  - **CERN based liaison with Machine** - Francois Butin;
  - **EXSO (GLIMOS)** - Richard Soluk;
  - **DEXSO-2** - Subash Behera;
  - **DEXSO-1** - Jack Lindon;
  - **Radiation Safety Officer** - Richard Soluk.
- **Installation Crew**
  - Richard Soluk - Crew leader and responsible for mechanics installation;
  - Paul Davis - Readout electronics, power supplies and FPGA based trigger;
  - Subash Behera - General team member to assist in all aspects of installation;
  - Emanuela Musumeci - General team member to assist in all aspects of installation

– Michael Staelens - General team member to assist in all aspects of installation
– Mitch Kelly - General team member to assist in all aspects of installation
– Phd-student/Post Doctoral student 1 - General team member to assist in all aspect of installation;
– Phd-student/Post Doctoral student 2 - General team member to assist in all aspect of installation.

5.6 Staging and Temporary Storage Area

To facilitate the installation and operation of the OD, the LHC machine site manager responsible for the allocation of surface space in the SBD building agreed that MoEDAL-MAPP Experiment can be temporarily attributed 20 m^2 of surface space in SBD 2855, as indicated in the photograph in Fig. 23. This

Fig. 23: The temporary staging area in SBD 2855.

area will be used as buffer space for short-term storage of equipment before transport and installation underground, and for storing light tooling needed for assembly and installation. The zone was cleared and fenced with mobile barriers and was made available to the collaboration in week-46 of 2021.

6 Maintenance and Operation of the Outrigger Detectors for MAPP-1 During Run-3

The MAPP-1 and OD will be read out via ethernet during the run to large-scale onsite disk storage at CERN. The UA83 gallery is not accessible during LHC running periods. In the event of a failure or malfunction of the OD, we will not be able to effect repair until we have a TS, or a YETS, in which access to the UA83 tunnel is possible. Typically, there are a few TSs within the year besides the YETS.

We could continue running with the failure of a large fraction of the readout channels although understandably this would compromise the physics performance of the detector. To reduce the risk of shutdown of data taking during the run, we have included in our electronics design a redundant power supply system and a redundant DAQ computer, to ensure robust operation of the overall detector.

To continue data taking in the event of a disruption of the ethernet connection, the DAQ server will have 60 TB of local disk storage. Data will be written to this disk until the ethernet connection is re-established. During normal running, the data rate will be well below 0.5 TB/day allowing an extended period of running without the need to export data to remote storage. Initially, the fewest possible restrictions will be applied to the trigger and the data rate will be limited by storage write speeds.

The MAPP detector is designed to be operated remotely and to shut down if any MAPP-1 or OD power supply draws more than a set maximum current. Nevertheless, the MAPP-1 and OD need to be monitored 24/7 by personnel based on site primarily for safety purposes, as described in Subsection 5.4. This is achieved by having a team of at least two physicists with MoEDAL-MAPP affiliation present at CERN full-time. So that at any time there is an on-call responsible while the machine is operating and during TSs. This team would be enhanced by an average of 0.5 FTE person, formed from MoEDAL-MAPP collaboration members who are visiting CERN and have the required safety training. For planned upgrades or maintenance during running periods, we will call on manpower resources described in Subsection 5.5.

6.1 The Outrigger Detector Control Centre

The base of operations of the MAPP detector is the MAPP Control Centre (MCC) in Bat. 17 R-007, the location of which is shown in Fig. 24. MAPP's

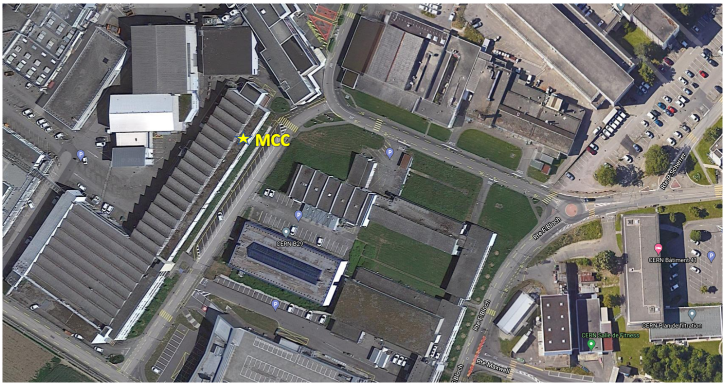


Fig. 24: The location of the MAPP Control Room (Bat. 17 R-007).

CERN-based operators have access through their on-call cell phones to the monitoring and alarm system as well as simple controls that allow them to turn off the power and alert the CCC. The on-call MAPP operator and the off-duty operator as well as the Technical Coordinator and Spokesperson also are connected to this system at all times via cellphone. During the day, the on-call MAPP-1 OD operator will usually sit in the control room. During the evening and night, the on-call will be connected by cell phone to the MAPP-1 and OD control and monitoring services. The on-call cell phone will be switched on at all times.

7 Funding Plans for the MoEDAL-MAPP Phase-1 Installation

The OD has been made possible by contributions of equipment from other experiments. First, a long-term loan of scintillator from the University of Alabama EXO-200 group and a long-term loan for surplus HZC PMTs acquired by an eventually unfunded astroparticle physics experiment. A grant supporting the procurement and fabrication of 60 machined scintillator slabs and their accompanying PMTs was received by the University of Alabama from the National Science Foundation (NSF), USA. We will use the same electronic readout, DAQ, calibration and safety systems utilized for MAPP-1. The funding needed for extra readout boards, PMT bases, LED calibration units and power supplies will be provided from MoEDAL-MAPP M&O funds, MoEDAL-MAPP-1's NSERC Discovery Grant to the University of Alberta, and contributions from the University of Alberta DUP funds. CERN has agreed to cover the cost of the material for, and installation of, the 1 m of iron shielding in Duct-4.

In terms of manpower, our project electronics engineer, mechanical engineer, and detector technologist are funded by the Alberta's existing NSERC MRS grant. The DEXSO full-time presence at CERN is funded by the Alabama's NSF grant. We have sufficient funds in hand to deploy the OD as described above to take data in Run-3.

8 Physics Issues

To fully understand the sensitivity of the MoEDAL-MAPP detector we are performing studies of a number of relevant physics benchmarks. Examples of initial benchmark studies are presented below. To complete these physics studies we need to fully and accurately simulate: the detector and its response; the passage of primary and secondary particles through the intervening infrastructure; and, the transport of cosmic ray particles through the 105 m overburden. The simulation framework is described below.

8.1 The Full Simulation of the UA83, MoEDAL, MAPP-1 Arena (SUMMA)

The SUMMA simulation is derived from the final CAD drawings of the MAPP-1 & OD, accurate CAD drawings of the machine infrastructure, and the existing model of cosmic ray transport through the overburden. In all, the simulation involves over 2500 elements. In addition, the physics processes relating to energy loss by all relevant charged and neutral particles has been implemented. The SUMMA code is available and under test.

The Physics Processes included in SUMMA, are:

- Primary Interaction and secondary particles, factory lists:
  - FTFP_Bert model of hadronic showers
  - QGSP_BERT_HP for neutron fluxes
- Transportation and Decay;
- Electromagnetic Interactions.
  - Gamma conversion, Compton scattering, photo-electric effect for gammas;
  - Multiple scattering, ionization, bremsstrahlung for electrons and annihilation for a positron;
  - Multiple scattering, ionization, bremsstrahlung and pair production for muons;
  - Multiple scattering and ionization for other particles.
- Scintillation processes
  - Scintillation and Cerenkov for particles;
  - Absorption, Rayleigh scattering, Mie scattering and boundary processes for optical photons.

The SUMMA ionization energy loss calculation for milli-charged particles is partially based on the approach adopted in the References [10, 11].

8.2 Mini-Charged Particles from Dark QED - a Physics Benchmark

An initial study of the sensitivity of the OD to mCPs is given in Fig. 25. There we consider a class of Feebly Interacting Particle (FIP) that has a fractional charge as small as $10^{-4}e$. A common scenario is from a Dark Sector model where one considers a mCP coupled through a very light kinetically mixed dark photon [12, 13]. Although the mCP does not carry SM electroweak quantum numbers, it behaves as a particle with a tiny electric charge. The Drell-Yan (DY) process provides the main production channel for GeV-range mCPs at the LHC, below which production in meson decays dominates. The sensitivities of MAPP-1 and the OD deployed at UA83 to particles produced in this way are shown in Fig. 25. As can be seen from the figure, the addition of the OD substantially increases sensitivity to heavier mCPs with charges above a few units of 10^{-3}.

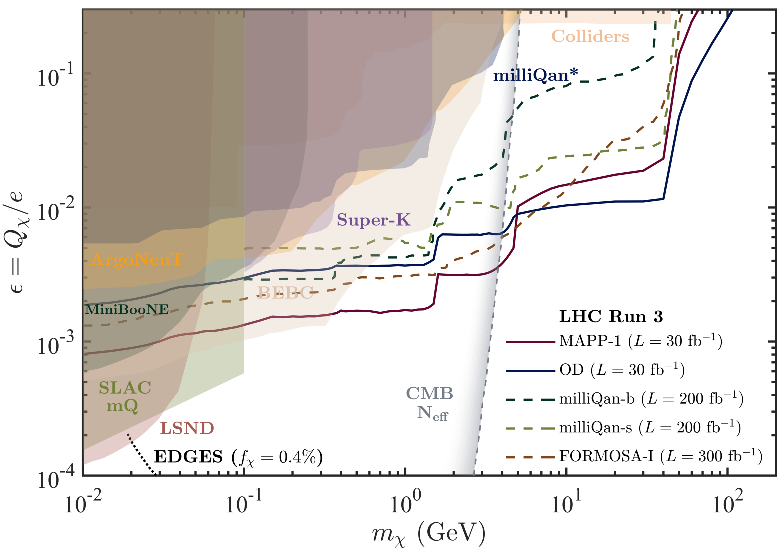


Fig. 25: Direct bounds from accelerator- and CR-based searches, as well as indirect bounds from the effective number of neutrinos from Planck are shown. The projected sensitivity for mCPs, for models with a massless dark photon, are presented for milliQan, MAPP-1, and FORMOSA-1 at Run-3. The existing bounds given here are described in more detail in Ref [14, 15].

Beside DY production, we include in our analysis the pair production of mini-charged particles from the direct decays of the Υ, J/ψ(nS), ψ(2S), ϕ, ρ, and ω, as well as single Dalitz decays of the π^0, η, and η'.

It should be noted that in Fig. 25 the detector efficiencies *have* been modelled for the MAPP-bar detector and the OD [15]. Backgrounds have not been taken into account in both cases. We expect the limits that we can place on the DY production of mini-charged particle pairs to soften slightly when this is done. As can be seen from Fig. 25, MAPP-1 is highly competitive with other mCP search experiments, especially at high masses.

Backgrounds

A potential source of background mentioned previously is the dark count from the PMT. For the HZC-photonics and Hamamatsu PMTs employed, in the MAPP-1 and OD, the dark count rate is typically ∼600 cps. Considering the mCP trigger, which consists of requiring an mCP signal in 4 collinear bars (MAPP-1) or blocks (OD) in coincidence, with a trigger window of 25 ns and a beam crossing rate of 40 MHz, we would expect a trigger rate due to the dark count rate in the PMTs of roughly 0.003 /yr, in a data-taking year of 1.5×10^7 s, in both detectors.

MAPP-1 is protected from collision-related backgrounds by approximately 45 m of concrete and the vertical veto counters in front of each section of the

MAPP-1 detector. The OD, enclosed in Duct-4, is protected from collision-related backgrounds by approximately 80 m of concrete.

The MAPP-1 and OD are both protected from cosmic ray (CR) backgrounds by a 105 m overburden. MilliQan, by comparison, is deployed near to the CMS detector at a depth of 73 m. The MoEDAL-MAPP simulation group has assessed the cosmic ray background expected in the MAPP-1 detector to be 4×10^{-5} cm^{-2} s^{-1}. This amounts to about 2 muons/s incident of the top of the MAPP-1 veto detector, with area $\sim$4.5 m^2. This rate is inconsistent with measurements taken in the UGC1 gallery in 2018. Considering the trigger requirement for mCPs and the high efficiency of the MAPP-1 veto system, the background from uncorrelated CR muons is expected to be negligible.

As the sensitive horizontal area of MAPP-1 (3 m^2) is roughly the same as the OD (2.5 m^2), we would expect roughly the same rate of muons through the top of the OD, i.e., roughly 2 muons/s, as through the top of the MAPP-1 Detector.

Another source of background is thought to be due to CR events with high muon multiplicity where many muons penetrating underground together. This has been observed, for example, by the ALICE [16] TPC with effective CR muon detection area of 17 m^2 and 28 m rock overburden. The concern is that many particles could impinge on the MAPP-1 and/or OD together, increasing the probability of satisfying the mCP trigger conditions. However, the greater the multiplicity of muons impinging on the MAPP-1 and OD region, the greater the chance one of these muons would veto the event. Several additional factors act to reduce this potential source of background:

- The rate of these showers is very small compared to the rate of single uncorrelated particles given above. For example, the ALICE data shows over six orders of magnitude fall in the number of events with a multiplicity of 20 muons compared to just a few muons.
- For CR muons from above or below to reach a bar and give even a small mCP signal the charged CR particle would normally need to cross two VETO counters which have an efficiency better than 99.7% and "clip" a bar. This would need to happen four times in four contiguous bars within the trigger time window, without hits from other CR muons in the shower registering in the VETO system;
- The rate of horizontal cosmic rays is greatly suppressed compared to the downward flux.
  - , If horizontal CR muons do reach MAPP-1, they must pass through four vertical veto walls of thickness 2.5 cm that are placed one in front of each of the four MAPP-1 sections and also the back wall of the cosmic ray VETO detector of thickness 1 cm. Additionally, they must at the same time conspire to mimic an mCP-like energy deposition to satisfy the mCP trigger;
  - As the OD is embedded in the 8 m thick wall between the UA83 and Beam tunnels the material protection is much greater. As with

MAPP-1, the CR muons would need to somehow appear as an mCP to satisfy the mCP signal.

- Neutrons associated with the muon shower can evade the VETO system and cause, for example, a nuclear recoil that can give rise to a small signal in a bar. This would need to happen in four contiguous bars within the trigger time window. At the same time, the accompanying charged particles in the shower would have to miss the VETO system.

For this background, we conservatively assume that any shower identified as multiple simultaneous signals from MAPP-1's side or top veto panels, would also affect the OD. Thus, we would use the veto signal from former to also veto the latter detectors. If necessary, we can utilize the outer layer of scintillator bars in MAPP-1 as an additional VETO system.

We can study non-beam-related background sources experimentally by running in the winter while the beam is off. In this way, we can directly register background events that mimic a signal. These runs can also be used to hone our estimates of non-beam-related backgrounds.

9 Conclusion

The MAPP-1 Outrigger Detector is designed to enhance the acceptance above a mCP mass of approximately 5 GeV/c^2 as shown in Fig. 25 for the standard benchmark process [12, 13] of DY production of mCP pairs.

MAPP-1 and OD are very competitive with the milliQan detector [19] that will also be deployed for Run-3 to cover a different pseudo-rapidity range. In the event mCPs are discovered by MAPP-1 and milliQan, a signal seen in two different detectors with their different systematics would provide the necessary confirmation of a discovery. Indeed, multiple experiments to verify important experimental findings have been adopted at LEP (ALEPH, DELPHI, L3 and OPAL) and at the LHC (ATLAS and CMS).

Although MAPP-1 is designed primarily to detect feebly ionizing particles such as mCPs, it also has some useful sensitivity for neutral LLPs, as shown in Fig. 26. It could, in some circumstances, confirm a signal observed by FASER [20] or vice versa. We are currently investigating using the OD to enhance the sensitivity of MAPP-1 to neutral LLPs. MAPP-2 is the last detector we are planning to propose as part of the MoEDAL-MAPP program for the high luminosity phase of the LHC, beyond Run-3. It is designed to search for LLPs in a globally competitive way. MAPP-2 will certainly greatly enhance MoEDAL-MAPP sensitivity to neutral LLPs compared to MAPP-1, as shown in Fig. 26.

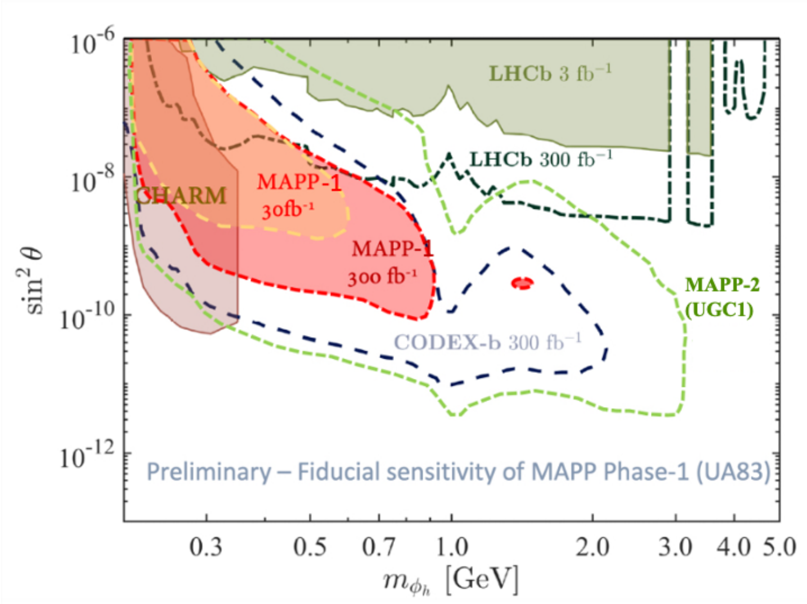


Fig. 26: MAPP-1 sensitivity plot for detection of a light scalar boson mixing with the Higgs boson, with three hits expected. Bounds from the CODEXb experiment are included for comparison, adapted from Fig. 3 published in Ref [17] . The exclusion bounds are shown here from the CHARM experiment considered a 400 GeV proton beam and 2.4×10^{18} POT [18].

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Appendix A

ECR for Shielding Installation

CERN
Esplanade des Particules 1
1217 Meyrin - Switzerland

EDMS NO.	REV.	VALIDITY
2962835	**0.2**	**DRAFT**

REFERENCE
LHC-X8MAPP-EC-0002

Date: 2023-10-19

ENGINEERING CHANGE REQUEST

MAPP Outrigger detector installation in UA83-LHC tunnel link ducts at LHC Pt 8

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

The MoEDAL collaboration has proposed to install a new set of detectors "MAPP outrigger" in the UA83-LHC tunnel link ducts at Point 8 of the LHC.
This document describes the changes required to accommodate the new project.

DOCUMENT PREPARED BY:	DOCUMENT TO BE CHECKED BY:	DOCUMENT TO BE APPROVED BY:
François BUTIN – BE-EA	James Pinfold – EP-UAT Richard Soluk – EP-UHC Eric Thomas – EP-LBO Markus Brugger – BE-EA Christelle Gaignant – BE-ASR Olga Beltramello – EP-DI Jean-Pierre Corso – EN-ACE Julie Coupard – EN-ACE Gael Girardot – EN-EL	EATM IEFC TREX

DOCUMENT SENT FOR INFORMATION TO:

James DEVINE, Evelyne DHO, Caterina Bertone; Alban Vieille

SUMMARY OF THE ACTIONS TO BE UNDERTAKEN:

[List the main actions to be undertaken]

Note: When approved, an Engineering Change Request becomes an Engineering Change Order.

This document is uncontrolled when printed. Check the EDMS to verify that this is the correct version before use.

1. EXISTING SITUATION AND INTRODUCTION

The MoEDAL experiment has been operating jointly with LHCb at LHC Pt8 since 2010, with little impact on infrastructure, mostly due to the joint efforts of the MoEDAL and LHCb collaborations. The MoEDAL collaboration installed the MAPP detector in the UA83 gallery in 2021. Installation is still ongoing, with most of the detector elements already in place, see EDMS 2617044.

The MoEDAL collaboration has expressed the intention to install some new experimental setup in 3 ex-ventilation ducts, linking the UA83 gallery with the LHC tunnel, see ref [1] and Figure 1 and Figure 2.

The installation of these new detector elements has a number of implications for what concerns the required infrastructure and in particular the shielding impacting both the experimental area and the LHC facilities.

The present ECR document concerns only Duct 4 to be instrumented during YETS 23-24. In case it proves successful, and depending on availability of other ducts, another ECR document will be produced accordingly.

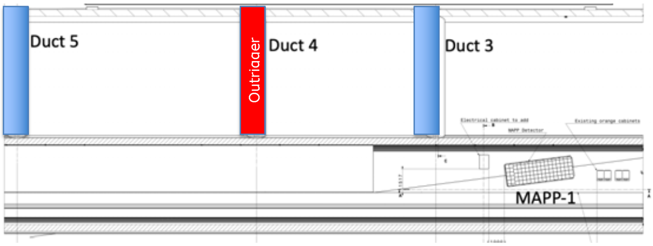


Figure 1 — Proposed location for MAPP Outrigger detectors between UA83 and LHC tunnel

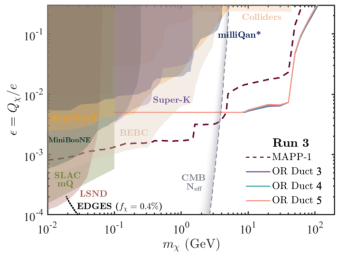


Figure 2 — Comparative simulations of MAPP Outrigger sensitivity to pp--> mcP+ + mcP- (via a Drell-Yan process)

2. REASON FOR THE CHANGE

The changes are a consequence of the evolution of the MoEDAL / MAPP 1 research programme and are intended to accommodate the evolution of the detection techniques and hardware.

3. DETAILED DESCRIPTION

The MAPP-1 Outrigger Detectors are proposed to be placed adjacent to the MAPP-1 detector in the duct A04L joining the beamline tunnel to the UA83 tunnel, as shown in Figure 4.

The basic scintillator unit of the Outrigger Detector is described in Figure 3. It comprises a block of acrylic scintillator (Bicron BC-412) of size 60 cm x 30 cm x 5 cm readout through a light guide by a single 3.5-inch low noise PMT (HZC Photonics XP82B2FNB). This unit is assembled on a frame with another unit for insertion on a rail into the shafts that house the Outrigger detectors. This subdivision is chosen to facilitate manual handling. The units are held at an angle of 45°.

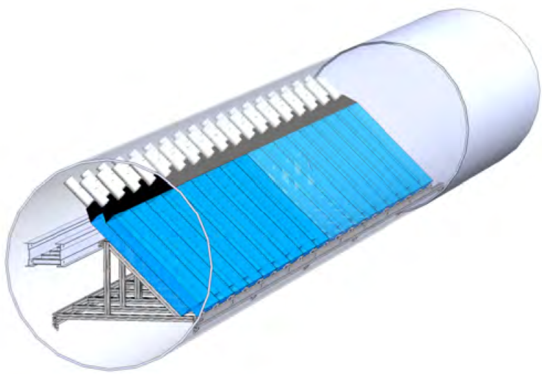


Figure 3 – Layout of the MAPP detector to be installed in A04L duct

These scintillator subunits are proposed to be installed in duct A04L joining the UA83 tunnel to the beam tunnel. Two scintillator layers will be inserted in duct 4, as shown in Figure 3.

It is to be noted that ducts A03L, A04L and A05L are not used at this stage, nor yet planned to be used at least till LS3, and have been blocked on the LHC tunnel side to avoid circulation of possibly contaminated air from the LHC tunnel to the UA83 gallery, see Figure 4. Nevertheless, it is wished at this stage that A03L and A05L are left free in case projects emerge beyond LS3, necessitating to route cables in this region.

This position may be reconsidered at a later stage, depending on the progress of the projects.

Figure 4 — Duct for MAPP Outrigger location, seen from LHC tunnel

Figure 5 — Duct for MAPP Outrigger location, seen from UA83

In order to reduce the beam induced background in the Outrigger detectors, it is requested to install shielding equivalent to a concrete shielding plug 2 m long in the duct concerned.

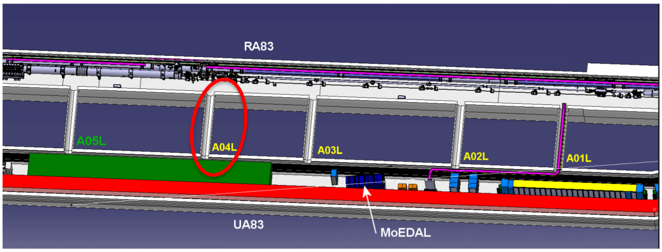


Figure 6— Duct A04L only is planned at this stage to be instrumented

In order for this shielding plug not to be permanent, it is proposed to be built out of shielding elements (iron bars and plates), that can possibly be removed at a later stage in case of need.

For ease of installation of the shielding, it will be required to remove the air-blocking panel visible on figure 4, that will be re-installed after the shielding material has been laid. 10 cm shall be left free so as to re-install this panel.

Similarly, the cable tray present in the duct will have to be removed prior to any survey or installation work can take place.

The shielding proposed for this first duct is constituted of iron bars and plates over a length of 1 m only, see Figure 7.

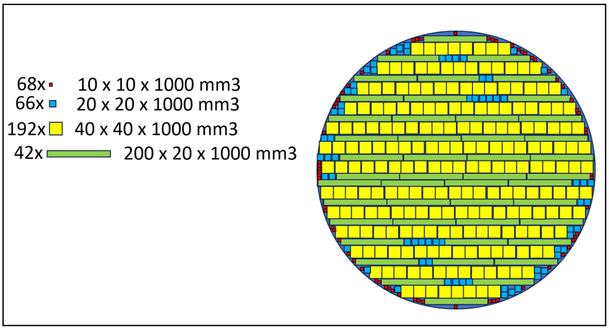
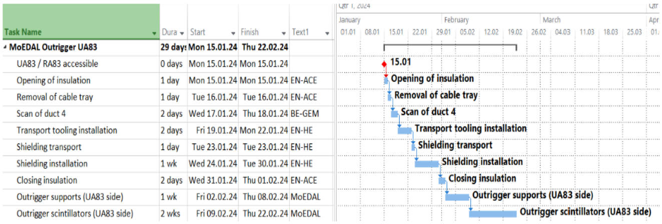


Figure 7— Filling pattern of duct A04L with iron bars

4. Installation schedule

A tentative installation schedule is shown in Figure 6.



Task Name	Dura	Start	Finish	Text1
MoEDAL Outrigger UA83	**29 days**	**Mon 15.01.24**	**Thu 22.02.24**	
UA83 / RA83 accessible	0 days	Mon 15.01.24	Mon 15.01.24	
Opening of insulation	1 day	Mon 15.01.24	Mon 15.01.24	EN-ACE
Removal of cable tray	1 day	Tue 16.01.24	Tue 16.01.24	EN-ACE
Scan of duct 4	2 days	Wed 17.01.24	Thu 18.01.24	BE-GEM
Transport tooling installation	2 days	Fri 19.01.24	Mon 22.01.24	EN-HE
Shielding transport	1 day	Tue 23.01.24	Tue 23.01.24	EN-HE
Shielding installation	1 wk	Wed 24.01.24	Tue 30.01.24	EN-HE
Closing insulation	2 days	Wed 31.01.24	Thu 01.02.24	EN-ACE
Outrigger supports (UA83 side)	1 wk	Fri 02.02.24	Thu 08.02.24	MoEDAL
Outrigger scintillators (UA83 side)	2 wks	Fri 09.02.24	Thu 22.02.24	MoEDAL

Figure 6 — Implementation schedule for the Outrigger detector and corresponding infrastructure (start date TBC)

5. IMPACT ON OTHER ITEMS

5.1 IMPACT ON UTILITIES AND SERVICES

Raw water:	No impact
Demineralized water:	No impact
Compressed air:	No impact
Electricity, cable pulling (power, signal, optical fibres...):	No impact
DEC/DIC:	Not needed
Racks (name and location):	No impact
Vacuum (bake outs, sectorisation...):	No impact
Special transport/ handling:	Handling of outrigger elements will be dealt with by the collaboration (light parts). The shielding elements handling will mostly depend on the retained type.
Temporary storage of conventional/radioactive components:	No impact
Alignment and positioning:	The alignment of the Outrigger detectors will necessitate the involvement of the survey group, using the network already in place for MAPP1 detector. A scan of the ducts will be required prior to installation.
Scaffolding:	The installation of shielding and Outrigger elements may require the use of temporary scaffolding in the UA83 gallery and/or LHC tunnel.

Controls:	No impact
GSM/WIFI networks:	No impact
Cryogenics:	No impact
Contractor(s):	The intervention of some contractors may be needed for the installation of the shielding.
Surface building(s):	No impact
Integration:	Integration drawings remain to be produced
Networks:	No impact

6. IMPACT ON COST, SCHEDULE AND PERFORMANCE

6.1 IMPACT ON COST

Detailed breakdown of the change cost:	Transport and handling	**5 kCHF**
	Shielding procurement	**9 kCHF**
	Survey / Alignment	**4 kCHF**
	Preparation /finishing work	**4 kCHF**
	Total	**22 kCHF**
Budget codes:	TBC	

6.2 IMPACT ON SCHEDULE

Proposed installation schedule:	During YETS 23-24 for duct 05, then TBC
Proposed test schedule (if applicable):	Tests will have to be performed on all safety related systems. The schedule will have to be detailed at a later stage.
Estimated duration:	The shielding installation works are expected to extend over a 2-3 weeks period. Other activities have a cumulated duration estimated to about 1 month.
Urgency:	Moderate
Flexibility of scheduling:	TBD

6.3 IMPACT ON PERFORMANCE

Mechanical aperture:	No impact

Impedance:	No impact
Optics/MADX	No impact
Electron cloud (NEG coating, solenoid…)	No impact
Insulation (enamelled flange, grounding…)	No impact
Vacuum performance:	No impact
R2E impact on performance and availability:	No impact
Others:	

7. IMPACT ON OPERATIONAL SAFETY

The creation of a new experimental area in UGC1 has a number of consequences on the operational safety, that are detailed in Annex 2.

7.1 ÉLÉMENT(S) IMPORTANT(S) DE SECURITÉ

Requirement	Yes	No	Comments
EIS-Access		X	
EIS-Beam		X	
EIS-Machine		X	

7.2 OTHER OPERATIONAL SAFETY ASPECTS

[This chapter aims at assessing the impact of the modification during operation and maintenance of the hardware on people safety, on the environment, including access, egress, circulation and evacuation.

It doesn't concern the installation of the hardware. Worksite safety is addressed in the next chapter.]

What are the hazards introduced by the hardware?	The MAPP outrigger detector is standard assembly of equipment, each of which are used already in many other places at CERN (scintillators, photo tubes etc). A preliminary safety analysis has been performed and is available on EDMS with number 2487833. The new hardware to be installed complies with CERN safety rules.
Could the change affect existing risk mitigation measures?	
What risk mitigation measures have to be put	

in place?	
Safety documentation to update after the modification	A safety file will have to be compiled for the MAPP Outrigger experiment.
Define the need for training or information after the change	The personnel intervening in UA83 gallery will need standard LHC tunnel safety training

8. WORKSITE SAFETY

[Refer to EDMS document: 1155899 – "Working on the CERN Site".]

8.1 ORGANISATION

Requirement	Yes	No	Comments
IMPACT – VIC:	X		To be organized for the various WP's
Operational radiation protection (surveys, DIMR…):		X	No ALARA classification
Radioactive storage of material:		X	None
Radioactive waste:	X		TBC if some parts of the ducts blocking material has to be evacuated
Non-radioactive waste:			None.
Fire risk/permit (IS41) (welding, grinding…):			To be checked when WP's will be described and VIC's organized.
Alarms deactivation/activation (IS37):			Not needed
Others:			

8.2 REGULATORY INSPECTIONS AND TESTS

Requirement	Yes	No	Responsible Group	Comments
HSE inspection of pressurised equipment:		X		
Pressure/leak tests:		X		
HSE inspection of electrical equipment:	X			The experiment will have to be inspected before HV can be switched on
Electrical tests:		X		

Others:				

8.3 PARTICULAR RISKS

Requirement	Yes	No	Comments
Hazardous substances (chemicals, gas, asbestos…):		X	
Work at height:	X		Installation of equipment in the ducts may require the usage of scaffolding or PIR's
Confined space working:		X	
Noise:		X	
Cryogenic risks:		X	
Industrial X-ray (*tirs radio*):		X	
Ionizing radiation risks (radioactive components):		X	[Traceability by TREC.]
Others:			

9. FOLLOW-UP OF ACTIONS BY THE TECHNICAL COORDINATION

Action	Done	Date	Comments
Carry out site activities:			
Carry out tests:			
Update layout drawings:			
Update equipment drawings:			
Update layout database:			
Update naming database:			
Update optics (MADX)			
Update procedures for maintenance and operations			
Update Safety File according to EDMS document 1177755:			
Others:			

10. REFERENCES

[1] MAPP Ourtigger Technical Proposal – EDMS XXXXXX, still to be published.

[2] Project Safety Requirement (PSR) MoEDAL MAPP and MALL detector - EDMS 2472788

Appendix B

Safety Derogation Request

EDMS **2631839** v.**1** status **Released** access **Restricted**
PDF from EDMS_2631839_MoEDAL_IS41_derogation_material_fire_v1.docx modified **2021-10-06 09:27**

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

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 is 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.

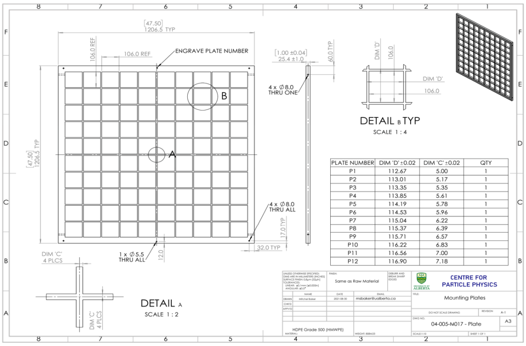


Figure 1: The drawing of one of 12 HDPE support grids of the MAPP-mQP detector

The weight of the scintillator in each section is supported by an aluminium T-bar support structure and a 0.5 cm aluminium plate that forms the base of each section. Additionally, each section is protected from the other by the lead-scintillator radiator plane that includes 2 x 1 mm of aluminium sheet and 5 x 2mm layers of lead. The active detector is completely encapsulated in VETO detectors comprised of 1 cm thick acrylic scintillator (Eljen-200 PVT based scintillator). with area roughly 30m^2. The above arrangement is shown in Figure 2. The support structures and metal plate elements are shown in blue. The HDPS support grids and metal support structures are further emphasized in Figure 3.

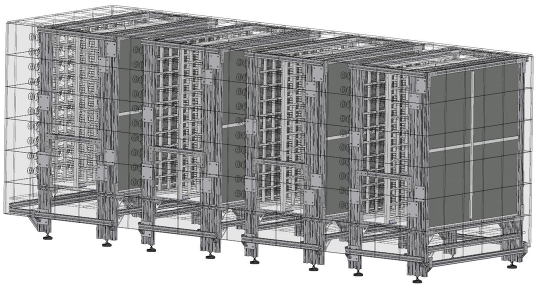


Figure 2: The basic structures of the MAPP-mQP with the outer VETO layer and the support structures emphasized

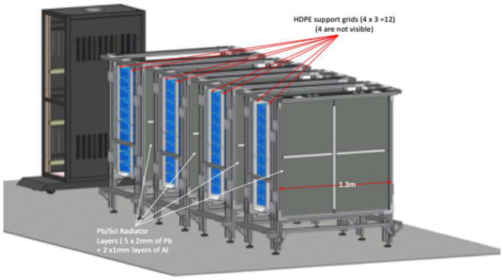


Figure 3 The basic structures of the MAPP-mQP without the outer VETO layer the support structures emphasized.

The MAPP detector and VETO layer are completely enclosed in the MAPP-mQP flame shield as shown in Figure 3. The size of the shield is roughly 1.3 x 1.5 x 4m. The flame-shield is fabricated out of 1mm thick aluminium sheet and has a total area of ~30 m^2. The aluminium encloses the plastic scintillator completely. There is no break in the flame shield for cable exit. The cables exit via a patch panel.

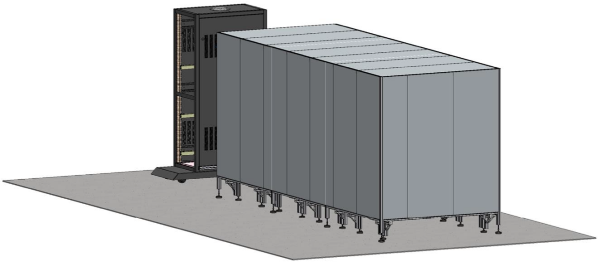


Figure 4 The flame shield around the MAPP-mQP detector

In order to provide a hermetic environment all joints in the flame shield are sealed using heavy duty aluminium tape shown in Figure 5. Any fires within the flame shield volume would be suppressed due to lack of oxygen. The slight electrical heating arising from the PMT bases within the volume of the flame shield – the only electrical elements in the region - amounts to a few hundred Watts that is dissipated by conduction and radiation from the flame shield surface

The foreseen location in UA83 is shown in Figure 5 and Figure 6 here below.

Figure 5: Proposed location in UL83

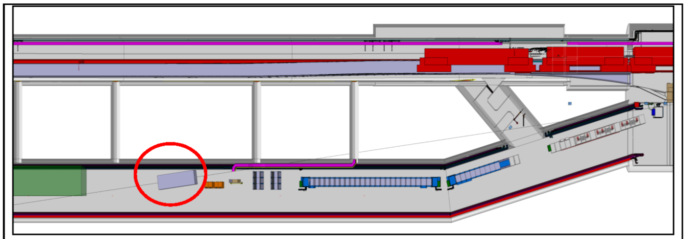


Figure 6: Proposed layout of the MAPP-mQP setup in UA83.

Further details on the materials used and other cases of applications at CERN are available in the document: **"Information Relating to Safety of the MAPP Detector With Respect to Flammability"** From J.Pinfold, available in this same EDMS node.

Further details on the installation in the UA83 are given in the ECR "LHC-X8MAPP-EC-0001 MoEDAL MAPP mQP detector in UA83" (EDMS 2617044).

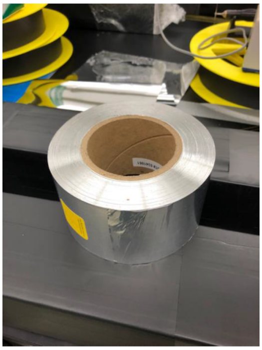


Figure 7 Heavy duty aluminium tape (0.25 mm thick). used to seal the flame shield

Gap compared with the reference regulation

Description:

Materials specifically needed for the MoEDAL Detector in virtue of their physical properties are not conforming to CERN IS 41:

Polystyrene (PS)

https://edms.cern.ch/ui/file/2631839/1/Polysyrene_Material_Data_Sheet-AMCRYS.pdf

High Density Polyethylene (HDPE) (https://edms.cern.ch/ui/file/2631839/1/Recycled_HDPE_Material_Safety_Data_Sheet.pdf) Polyvinyl Toluene (PVT) https://edms.cern.ch/ui/file/2631839/1/EJ-200-SDS_PVT_Material_Safety_Data_Sheet.pdf Cause and justification of the gap: PS is required for the operation of scintillation detectors in order to perform physics in MoEDAL Experiment

Quantity : (kg or m^3) 3,000 kgs of PS HDPE 326kg PVT 406kg	**Dimensions :** (length, width, diameter, thickness) PS: 10 x 10 x 75 cm / 100 units x 4 HDPE: support spacers grids --various measures described in Figure 1 PVT: set of plates, 1cm thick, total 30m^2

Ignition sources: Low Voltage circuitry Distance to the nearest external powered system: An uninterruptible power supply, part of other LHC equipment, is at a distance ~1.5 m
Are there other previous derogation requests for the equipment/building/installation…? Not for this installation (A previous derogation has been made for MoEDAL in UX85 EDMS 893563)
What are the alternatives that have been investigated and why were they not put into place ? The scintillators for the detector are housed within a flame-resistant metal casing, to prevent the propagation of fire. This mitigation is considered in the context of the derogation request required from HSE. This measure is integral to the detector and does not require any external mitigation measures. The material properties of PS are required for scintillator detectors of this type, no other alternative is possible.
Documents provided by the requestor: Click or tap here to enter text.

APPLICABLE SAFETY DOMAIN *(a single domain per derogation)*		
☐ Mechanical (pressure, lifting, machines, HVAC…) ☐ Cryogenics ☐ Structural, civil engineering ☒ Fire Safety ☐ Chemical	☐ Workplace ☐ Flammable gas ☐ ODH ☐ Electrical ☐ Noise	☐ Non-ionising radiation ☐ Environmental protection ☐ Others: Click or tap here to enter text.

HSE
Occupational Health & Safety
and Environmental Protection Unit

SPECIALIST OPINION

Specialist:
Fabio CORSANEGO HSE-OHS-IB Jonathan Gulley HSE-OHS-PE

Specialist opinion:
Acceptable with the conditions agreed here below

Compensatory measures defined in collaboration with the requestor:

safeguards: hardware/software interlocks

power supplies are low voltage (24V), are current and temperature limited (turn off when current or temperature goes out of range) and provide an alarm signal when current or voltage moves out of some predefined *operating window*.

handover of alarms generated by the system

Three types of warning/alarm information will be provided to the CCC:

1) The current/voltage and temperature readings/alarms from the power supplies,
2) The hermetic metal flame shield is monitored by temperature sensors placed on the outside of the shield. The output of these temperature sensors will also be provided to the CCC,
3) There is a plan (not yet confirmed) to monitor the detectors + electronics with an IR camera whose output is provided to the CCC.

Other safeguards:

1) The power supplies, readout electronics and other non MoEDAL live equipment present in UA83 are separated by a distance of 1.5 m from the detector,
2) The only entities that use power in the detector volume are PMT bases. Power supplied to the bases is LV and only stopped up in the base,
3) The detector volume is completely encased in a hermetic (sealed to exclude air movement) flame shield. Cables enter the volume via a patch panel. Metal planes separate each of the four compartments of the detector. A strong metal plate forms the base of the scintillator bar compartments.

Conditions for the validity of the derogation :

☐ Temporary derogation - expiry date : Click or tap to enter a date.
☒ Permanent derogation

Description of the conditions for retaining validity:
Observance of the conditions defined in this document

Documents applicable to the reply:

TRACEABILITY

Reference and version EDMS : https://edms.cern.ch/document/2631839/1

STATUS OF THE DEROGATION

See EDMS

Appendix C Plastic Scintillator Safety Data Sheet

Safety Data Sheet

SAINT-GOBAIN

Section 1: Identification of the Substance/Mixture and of the Company/Undertaking

1.1 Product identifier

Product Name • **Polyvinyl Toluene & Organic Fluors**

Synonyms • Plastic Scintillators

Product Code • BC-400; BC-400 B; BC-400V; BC-404; BC-404 A; BC-404 B; BC-404 C; BC-404 CIM; BC-404 V; BC-404VM; BC-408; BC-408 A; BC-408 LB; BC-408 NS; BC-408 S; BC-408 V; BC-412; BC-412 IM; BC-414; BC-414 A; BC-416; BC-418; BC-420; BC-422; BC-422A; BC-428; BC-428 V; BC-428 VM; BC-428 M; BC-430; BC-444A; BC-444G; BC-444M; BC-446; BC-488; BC-49901; BC-49906; BC-49909; BC-49910; BC-49918; BC-49953; BC-49977; BC-49978; BC-49979; BC-49980; BC-49983; BC-49985; BC-49986; BC-49988; BC-810; BC-444

1.2 Relevant identified uses of the substance or mixture and uses advised against

Relevant identified use(s) • Radiation detection

1.3 Details of the supplier of the safety data sheet

Manufacturer • Saint-Gobain Crystals

17900 Great Lakes Parkway
Hiram, OH 44234
United States
www.crystals.saint-gobain.com
scintillation@saint-gobain.com

Telephone (General) • 440-834-5600

1.4 Emergency telephone number

Manufacturer • 1-800-424-9300 - ChemTrec

Manufacturer • 703-525-3887 - Outside U.S.

Section 2: Hazards Identification

EU/EEC

According to: Regulation (EC) No 1272/2008 (CLP)/REACH 1907/2006 [amended by 453/2010]
According to: EU Directive 67/548/EEC (DSD) or 1999/45/EC (DPD)

2.1 Classification of the substance or mixture

CLP • Not classified

DSD/DPD • Not classified

2.2 Label Elements

CLP

Hazard statements • No label element(s) required

DSD/DPD

Risk phrases • No label element(s) required

2.3 Other Hazards

CLP • According to Regulation (EC) No. 1272/2008 (CLP) this material is not considered hazardous.

DSD/DPD • According to European Directive 1999/45/EC this preparation is not considered dangerous.

United States (US)

According to: OSHA 29 CFR 1910.1200 HCS

2.1 Classification of the substance or mixture

OSHA HCS 2012 • Not classified

2.2 Label elements

OSHA HCS 2012

Hazard statements • No label element(s) required

2.3 Other hazards

OSHA HCS 2012 • This product is not considered hazardous under the U.S. OSHA 29 CFR 1910.1200 Hazard Communication Standard.

Canada

According to: WHMIS

2.1 Classification of the substance or mixture

WHMIS • Not classified

2.2 Label elements

WHMIS • No label element(s) required.

2.3 Other hazards

WHMIS • In Canada, the product mentioned above is not considered hazardous under the Workplace Hazardous Materials Information System (WHMIS).

Section 3 - Composition/Information on Ingredients

3.1 Substances

• Material does not meet the criteria of a substance.

3.2 Mixtures

Composition					
Chemical Name	**Identifiers**	**%**	**LD50/LC50**	**Classifications According to Regulation/Directive**	**Comments**
Vinyl toluene	**CAS:**25013-15-4	93.8539% TO 99.964%	Ingestion/Oral-Rat LD50 • 2255 mg/kg	**EU DSD/DPD:** Xi; R36/37/38; R67 **EU CLP:** Flam. Liq. 3, H226; Skin Irrit. 2, H315; STOT SE 3: Resp. Irrit., H335; STOT SE 3: Narc., H336	NDA

				OSHA HCS 2012: Flam. Liq. 3; Eye Irrit. 2; Skin Irrit. 2; STOT SE 3: Resp. Irrit.& Narc.	
Organic fluors	*Proprietary*	0% TO 5.0989%	NDA	**EU DSD/DPD:** Not Classified **EU CLP:** Not Classified **OSHA HCS 2012:** Not Classified	NDA
Organic fluors	*Proprietary*	0% TO 3.7893%	NDA	**EU DSD/DPD:** Xi; R38 **EU CLP:** Skin Irrit. 2, H315 **OSHA HCS 2012:** Skin Irrit. 2	NDA
Organic fluors	*Proprietary*	0% TO 3.2482%	NDA	**EU DSD/DPD:** Xn; R22 **EU CLP:** Acute Tox. 4, H302 **OSHA HCS 2012:** Acute Tox. 4 (orl)	NDA
Organic fluors	*Proprietary*	0% TO 2.6769%	NDA	**EU DSD/DPD:** Not Classified **EU CLP:** Not Classified **OSHA HCS 2012:** Not Classified	NDA
Organic fluors	*Proprietary*	0% TO 2.4524%	NDA	**EU DSD/DPD:** Xi; R36/37/38 **EU CLP:** Skin Irrit. 2, H315; Eye Irrit. 2, H319; STOT SE 3: Resp. Irrit., H335 **OSHA HCS 2012:** Eye Irrit. 2; Skin Irrit. 2; STOT SE 3: Resp. Irrit.	NDA
Organic fluors	*Proprietary*	0% TO 0.5501%	NDA	**EU DSD/DPD:** Not Classified **EU CLP:** Not Classified **OSHA HCS 2012:** Not Classified	NDA
Organic fluors	*Proprietary*	0% TO 0.2184%	NDA	**EU DSD/DPD:** Xn; R22 **EU CLP:** Acute Tox. 4, H302 **OSHA HCS 2012:** Acute Tox. 4 (orl)	NDA
Organic fluors	*Proprietary*	0% TO 0.112%	NDA	**EU DSD/DPD:** Not Classified **EU CLP:** Not Classified **OSHA HCS 2012:** Not Classified	NDA
Organic fluors	*Proprietary*	0% TO 0.11%	NDA	**EU DSD/DPD:** Not Classified **EU CLP:** Not Classified **OSHA HCS 2012:** Not Classified	NDA
Organic fluors	*Proprietary*	0% TO 0.11%	Skin-Rabbit LD50 • >5 g/kg Ingestion/Oral-Rat LD50 • 4600 mg/kg	**EU DSD/DPD:** Xi; R38 **EU CLP:** Skin Irrit. 2, H315 **OSHA HCS 2012:** Skin Irrit. 2	NDA
Organic fluors	*Proprietary*	0% TO 0.05599%	NDA	**EU CLP:** Community workplace exposure limit **OSHA HCS 2012:** Exposure limit	NDA
Organic fluors	*Proprietary*	0% TO 0.0442%	Ingestion/Oral-Rat LD50 • >10 g/kg	**EU CLP:** Community workplace exposure limit **OSHA HCS 2012:** Exposure limits	NDA
Organic fluors	*Proprietary*	0.0311% TO 0.0336%	Ingestion/Oral-Rat LD50 • 890 mg/kg	**EU CLP:** Community workplace exposure limit **OSHA HCS 2012:** Exposure limits	NDA

See Section 16 for full text of H-statements and R-phrases.

Section 4 - First Aid Measures

4.1 Description of first aid measures

Inhalation
- Move victim to fresh air. Give artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult. If signs/symptoms continue, get medical attention.

Skin
- Wash skin with soap and water. If irritation develops and persists, get medical attention.

Eye
- Flush eyes with water for at least 15 minutes while holding eyelids open. If eye irritation persists: Get medical advice/attention.

Ingestion
- Obtain medical attention immediately if ingested.

4.2 Most important symptoms and effects, both acute and delayed

- Refer to Section 11 - Toxicological Information.

4.3 Indication of any immediate medical attention and special treatment needed

Notes to Physician
- All treatments should be based on observed signs and symptoms of distress in the patient. Consideration should be given to the possibility that overexposure to materials other than this product may have occurred.

Section 5 - Firefighting Measures

5.1 Extinguishing media

Suitable Extinguishing Media
- Water fog, carbon dioxide, foam, dry chemical.

Unsuitable Extinguishing Media
- No data available.

5.2 Special hazards arising from the substance or mixture

Unusual Fire and Explosion Hazards
- None known.

Hazardous Combustion Products
- Plastic will burn and produce noxious smoke.

5.3 Advice for firefighters

- Wear positive pressure self-contained breathing apparatus (SCBA).
  Structural firefighters' protective clothing will only provide limited protection.

Section 6 - Accidental Release Measures

6.1 Personal precautions, protective equipment and emergency procedures

Personal Precautions
- Ventilate the area before entry. Do not walk through spilled material. Wear appropriate personal protective equipment, avoid direct contact.

Emergency Procedures
- As an immediate precautionary measure, isolate spill or leak area for at least 25 meters (75 feet) in all directions. Keep unauthorized personnel away.

6.2 Environmental precautions

- Avoid release to the environment.

6.3 Methods and material for containment and cleaning up

Containment/Clean-up Measures
- Avoid generating dust.
  SMALL DRY SPILLS: With clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
  LARGE SPILLS: Cover powder spill with plastic sheet or tarp to minimize spreading.

6.4 Reference to other sections

- Refer to Section 8 - Exposure Controls/Personal Protection and Section 13 - Disposal Considerations.

Section 7 - Handling and Storage

7.1 Precautions for safe handling

Handling
- Use only with adequate ventilation. Minimize dust generation and accumulation. Wear appropriate personal protective equipment, avoid direct contact. Wash thoroughly with soap and water after handling and before eating, drinking, or using tobacco.

7.2 Conditions for safe storage, including any incompatibilities

Storage
- Store in a cool, dry, well ventilated area.

7.3 Specific end use(s)

- Refer to Section 1.2 - Relevant identified uses.

Section 8 - Exposure Controls/Personal Protection

8.1 Control parameters

Exposure Limits/Guidelines				
	Result	ACGIH	NIOSH	OSHA
Organic fluors (Proprietary)	TWAs	Not established	10 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable dust)	15 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable fraction)
Organic fluors (Proprietary)	TWAs	10 ppm TWA	10 ppm TWA; 50 mg/m3 TWA	Not established
Organic fluors (Proprietary)	Ceilings	Not established	0.5 ppm Ceiling; 5 mg/m3 Ceiling	Not established
Organic fluors (Proprietary)	TWAs	2 mg/m3 TWA (inhalable fraction and vapor)	10 mg/m3 TWA	Not established
Vinyl toluene (25013-15-4)	TWAs	50 ppm TWA	100 ppm TWA; 480 mg/m3 TWA	100 ppm TWA; 480 mg/m3 TWA
	STELs	100 ppm STEL	Not established	Not established

Exposure Control Notations

ACGIH

- Vinyl toluene (25013-15-4): **Carcinogens:** (A4 - Not Classifiable as a Human Carcinogen)
- Organic fluors (Proprietary): **Carcinogens:** (A4 - Not Classifiable as a Human Carcinogen)

Exposure Limits Supplemental

ACGIH

- Vinyl toluene (25013-15-4): **TLV Basis - Critical Effects:** (eye and upper respiratory tract irritation)
- Organic fluors (Proprietary): **TLV Basis - Critical Effects:** (upper respiratory tract irritation)
- Organic fluors (Proprietary): **TLV Basis - Critical Effects:** (upper respiratory tract irritation)

8.2 Exposure controls

Engineering Measures/Controls
- Adequate ventilation systems as needed to control concentrations of airborne contaminants below applicable threshold limit values. Ensure that dust handling systems (such as exhaust ducts, dust collectors, vessels and processing equipment) are designed in a manner to prevent the escape of dust into the work area (i.e., there is not leakage from the equipment).

Personal Protective Equipment

Respiratory
- For limited exposure use an N95 dust mask. For prolonged exposure use an air-purifying respirator with high efficiency particulate air (HEPA) filters. Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or symptoms are experienced.

Eye/Face
- Wear safety goggles.

Skin/Body
- Wear appropriate gloves. Wear long sleeves and/or protective coveralls.

Environmental Exposure Controls
- Follow best practice for site management and disposal of waste.

Key to abbreviations

ACGIH = American Conference of Governmental Industrial Hygiene	STEL = Short Term Exposure Limits are based on 15-minute exposures
NIOSH = National Institute of Occupational Safety and Health	TLV = Threshold Limit Value determined by the American Conference of Governmental Industrial Hygienists (ACGIH)
OSHA = Occupational Safety and Health Administration	TWA = Time-Weighted Averages are based on 8h/day, 40h/week exposures

Section 9 - Physical and Chemical Properties

9.1 Information on Physical and Chemical Properties

Material Description			
Physical Form	Solid	Appearance/Description	Clear, fluorescent solid plastic, with no odor.
Color	Clear, fluorescent.	Odor	No odor.
Odor Threshold	Data lacking		
General Properties			
Boiling Point	Data lacking	Melting Point	Data lacking
Decomposition Temperature	Data lacking	pH	Data lacking
Specific Gravity/Relative Density	= 1.03 Water=1	Water Solubility	Data lacking
Viscosity	Data lacking	Explosive Properties	Data lacking
Oxidizing Properties:	Data lacking		
Volatility			
Vapor Pressure	Data lacking	Vapor Density	Data lacking
Evaporation Rate	Data lacking		
Flammability			
Flash Point	Data lacking	UEL	Data lacking
LEL	Data lacking	Autoignition	Data lacking
Flammability (solid, gas)	Data lacking		
Environmental			
Octanol/Water Partition coefficient	Data lacking		

9.2 Other Information

- No additional physical and chemical parameters noted.

Section 10: Stability and Reactivity

10.1 Reactivity

- No dangerous reaction known under conditions of normal use.

10.2 Chemical stability

- Stable under normal temperatures and pressures.

10.3 Possibility of hazardous reactions

- Hazardous polymerization not indicated.

10.4 Conditions to avoid

- Temperatures over 300º C.

10.5 Incompatible materials

- Strong oxidizers.

10.6 Hazardous decomposition products

- Carbon dioxide and carbon monoxide, hydrocarbons.

Section 11 - Toxicological Information

11.1 Information on toxicological effects

Components		
Vinyl toluene (93.8539% TO 99.964%)	25013-15-4	**Acute Toxicity:** Ingestion/Oral-Rat LD50 • 2255 mg/kg; *Sense Organs and Special Senses:Eye*:**Lacrimation**; *Behavioral*:**Somnolence (general depressed activity)**; *Skin and Appendages:Other*:**Hair**; **Irritation:** Eye-Rabbit • 90 mg • Mild irritation; Skin-Rabbit • 100 % • Moderate irritation
Organic fluors (0% TO 3.2482%)	*Proprietary*	**Acute Toxicity:** Ingestion/Oral-Rat LD50 • 1000 mg/kg; *Liver*:**Changes in liver weight**
Organic fluors (0% TO 3.7893%)	*Proprietary*	**Acute Toxicity:** Ingestion/Oral-Rat LD50 • 32 g/kg; **Reproductive:** Ingestion/Oral-Rat TDLo • 418 g/kg (10W male/10D pre); *Reproductive Effects:Effects on Newborn*:**Growth statistics (e.g., reduced weight gain)**
Organic fluors (0% TO 0.11%)	*Proprietary*	**Acute Toxicity:** Ingestion/Oral-Rat LD50 • 4600 mg/kg; Skin-Rabbit LD50 • >5 g/kg; **Irritation:** Skin-Rabbit • 500 mg 24 Hour(s) • Moderate irritation; **Mutagen:** DNA damage • Unreported Route-Human • Liver (Somatic cell) • 10 mg/L 20 Hour(s); **Tumorigen / Carcinogen:** Implant-Mouse TDLo • 400 mg/kg; *Tumorigenic*:**Equivocal tumorigenic agent by RTECS criteria**; *Kidney, Ureter, and Bladder*:**Tumors**
Organic fluors (0% TO 0.2184%)	*Proprietary*	**Acute Toxicity:** Ingestion/Oral-Rat LD50 • 1500 mg/kg; **Multi-dose Toxicity:** Ingestion/Oral-Rat TDLo • 33000 mg/kg 33 Day(s)-Intermittent; *Liver*:**Other changes**; *Kidney, Ureter, and Bladder*:**Other changes**; *Nutritional and Gross Metabolic:Gross Metabolite Changes*:**Weight loss or decreased weight gain**; **Reproductive:** Ingestion/Oral-Rat TDLo • 1100 mg/kg (1-22D preg); *Reproductive Effects:Specific Developmental Abnormalities*:**Cardiovascular (circulatory) system**
Organic fluors (0% TO 2.4524%)	*Proprietary*	**Acute Toxicity:** Ingestion/Oral-Rat LD50 • 5 mL/kg; **Mutagen:** Micronucleus test • Inhalation-Mouse • 53 ppm 6 Hour(s) 3 Day(s)-Continuous; Cytogenetic analysis • Inhalation-Mouse • 53 ppm 6 Hour(s) 3 Day(s)-Continuous; Sister chromatid exchange • Inhalation-Mouse • 53 ppm 6 Hour(s) 3 Day(s)-Continuous

GHS Properties	Classification
Acute toxicity	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking
Aspiration Hazard	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking
Carcinogenicity	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking
Germ Cell Mutagenicity	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking
Skin corrosion/Irritation	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking
Skin sensitization	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking
STOT-RE	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking
STOT-SE	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking
Toxicity for Reproduction	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking
Respiratory sensitization	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking

Serious eye damage/Irritation	**EU/CLP** • Data lacking **OSHA HCS 2012** • Data lacking

Potential Health Effects

Inhalation

Acute (Immediate)	• Processes such as cutting, grinding, crushing, or impact may result in generation of excessive amounts of airborne dusts in the workplace. Nuisance dust may affect the lungs but reactions are typically reversible.
Chronic (Delayed)	• Repeated and prolonged exposure to dust may cause lung effects including pneumoconiosis.

Skin

Acute (Immediate)	• Exposure to dust may cause mechanical irritation.
Chronic (Delayed)	• No data available.

Eye

Acute (Immediate)	• Exposure to dust may cause mechanical irritation. Excessive concentrations of nuisance dust in the workplace may reduce visibility and may cause unpleasant deposits in eyes.
Chronic (Delayed)	• No data available.

Ingestion

Acute (Immediate)	• Excessive concentrations of nuisance dust in the workplace may cause mechanical irritation to mucous membranes.
Chronic (Delayed)	• No data available.

Key to abbreviations

LD = Lethal Dose

TD = Toxic Dose

Section 12 - Ecological Information

12.1 Toxicity

- Material data lacking.

12.2 Persistence and degradability

- Material data lacking.

12.3 Bioaccumulative potential

- Material data lacking.

12.4 Mobility in Soil

- Material data lacking.

12.5 Results of PBT and vPvB assessment

- No PBT and vPvB assessment has been conducted.

12.6 Other adverse effects

- No studies have been found.

Section 13 - Disposal Considerations

13.1 Waste treatment methods

Product waste	• Dispose of content and/or container in accordance with local, regional, national, and/or international regulations.

Packaging waste
- Dispose of content and/or container in accordance with local, regional, national, and/or international regulations.

Section 14 - Transport Information

	14.1 UN number	14.2 UN proper shipping name	14.3 Transport hazard class(es)	14.4 Packing group	14.5 Environmental hazards
DOT	NDA	Not Regulated	NDA	NDA	NDA
TDG	NDA	Not Regulated	NDA	NDA	NDA
IMO/IMDG	NDA	Not Regulated	NDA	NDA	NDA
IATA/ICAO	NDA	Not Regulated	NDA	NDA	NDA

14.6 Special precautions for user
- None specified.

14.7 Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code
- No data available

Section 15 - Regulatory Information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

SARA Hazard Classifications
- None

Inventory						
Component	**CAS**	**Canada DSL**	**Canada NDSL**	**EU EINECS**	**EU ELNICS**	**TSCA**
Organic fluors	*Proprietary*	Yes	No	Yes	No	Yes
Organic fluors	*Proprietary*	Yes	No	Yes	No	Yes
Organic fluors	*Proprietary*	No	No	Yes	No	No
Organic fluors	*Proprietary*	No	Yes	Yes	No	Yes
Organic fluors	*Proprietary*	Yes	No	Yes	No	Yes
Organic fluors	*Proprietary*	Yes	No	Yes	No	Yes
Organic fluors	*Proprietary*	No	Yes	Yes	No	Yes
Organic fluors	*Proprietary*	No	No	No	No	No
Organic fluors	*Proprietary*	Yes	No	Yes	No	Yes
Organic fluors	*Proprietary*	Yes	No	Yes	No	Yes
Organic fluors	*Proprietary*	Yes	No	Yes	No	Yes
Organic fluors	*Proprietary*	Yes	No	Yes	No	Yes
Vinyl toluene	25013-15-4	Yes	No	Yes	No	Yes
Organic fluors	*Proprietary*	Yes	No	Yes	No	Yes

Canada

Labor

Canada - WHMIS - Classifications of Substances

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Uncontrolled product according to WHMIS

		classification criteria
• Vinyl toluene	25013-15-4	B3, D2B
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Uncontrolled product according to WHMIS classification criteria
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Uncontrolled product according to WHMIS classification criteria
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

Canada - WHMIS - Ingredient Disclosure List

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	1 %
• Vinyl toluene	25013-15-4	1 %
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	1 %
• Organic fluors	*Proprietary*	1 %
• Organic fluors	*Proprietary*	1 %
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	1 %
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

Environment

Canada - CEPA - Priority Substances List

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

United States

Labor

U.S. - OSHA - Process Safety Management - Highly Hazardous Chemicals

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - OSHA - Specifically Regulated Chemicals

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

Environment

U.S. - CAA (Clean Air Act) - 1990 Hazardous Air Pollutants

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - CERCLA/SARA - Hazardous Substances and their Reportable Quantities

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	5000 lb final RQ; 2270 kg final RQ
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - CERCLA/SARA - Radionuclides and Their Reportable Quantities

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - CERCLA/SARA - Section 302 Extremely Hazardous Substances EPCRA RQs

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	5000 lb EPCRA RQ
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - CERCLA/SARA - Section 302 Extremely Hazardous Substances TPQs

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	1000 lb lower TPQ; 10000 lb upper TPQ
• Organic fluors	*Proprietary*	Not Listed

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - CERCLA/SARA - Section 313 - Emission Reporting

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - CERCLA/SARA - Section 313 - PBT Chemical Listing

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

United States - California

Environment

U.S. - California - Proposition 65 - Carcinogens List

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - California - Proposition 65 - Developmental Toxicity

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - California - Proposition 65 - Maximum Allowable Dose Levels (MADL)

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - California - Proposition 65 - No Significant Risk Levels (NSRL)

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

U.S. - California - Proposition 65 - Reproductive Toxicity - Female

• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
U.S. - California - Proposition 65 - Reproductive Toxicity - Male		
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Vinyl toluene	25013-15-4	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed
• Organic fluors	*Proprietary*	Not Listed

15.2 Chemical Safety Assessment

- No Chemical Safety Assessment has been carried out.

Section 16 - Other Information

Relevant Phrases (code & full text)

- H226 - Flammable liquid and vapour
  H302 - Harmful if swallowed
  H315 - Causes skin irritation
  H319 - Causes serious eye irritation
  H335 - May cause respiratory irritation
  H336 - May cause drowsiness or dizziness
  R22 - Harmful if swallowed.
  R36/37/38 - Irritating to eyes, respiratory system and skin.
  R38 - Irritating to skin.
  R67 - Vapours may cause drowsiness and dizziness.

Last Revision Date
- 01/June/2015

Preparation Date
- 01/June/2015

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Key to abbreviations

NDA = No data available