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M2 User Guide

The M2 beam is a secondary or tertiary beam that can provide to the experiment in experimental hall EHN2 one of the following types of beam:

1. A high-intensity **muon beam** in the momentum range ±60 to ±190 GeV/c with fluxes up to 2 10^8 muons per SPS cycle, depending on the momentum chosen and limited by radio-protection guidelines,
2. A secondary **hadron beam** of momenta between ±40 and ±280 GeV/c at a maximum allowed flux of 10^8 hadrons per SPS cycle,
3. A low-intensity **electron calibration beam** (typically 10^3 to 10^4 electrons per SPS cycle), of momenta up to -60 GeV/c. *Note that the quality of the electron beams is limited by the large amount of air and material on the beam line.*

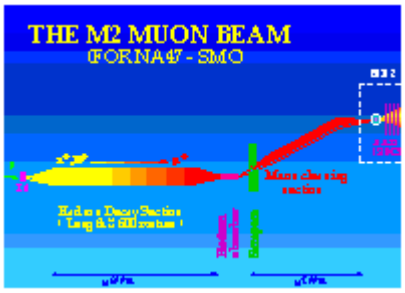
The M2 has recently been modified significantly to better match the needs of the COMPASS experiment (NA58). A description of these modifications is available on the Web

This User Guide gives an introduction to the use and operation of the M2 beam. The beam is controlled through the Cesar application. The Cesar application, pre-configured for your beam line, starts automatically upon booting of the beam PC in the COMPASS control room. General guidelines on how to control beam lines through the Cesar interface are available in a separate document, "How to control the North Area beam lines", which the present document complements with M2 specific items.

1. The layout of the M2 beam.

A 400 GeV/c primary proton beam is extracted from the SPS towards the North Experimental Area. A fraction of this beam, selected by two stages of septum magnets, is directed towards the primary target **T6**. The proton intensity incident on this target is decided by the SPS coordinator and may be in the range between 2 10^{12} and 1.45 10^{13} protons per SPS cycle. For a proper operation of the M2 beam the symmetry of the beam on target should be about 80%, as can be checked from the so-called Page1 screens in the control room (explanations are available here). From the T6 target a secondary beam (positive or negative) at zero production angle is derived. This beam is either transported directly to the experiment (in the case of the hadron beam), or tertiary muons or electrons are selected.

A schematic layout of the M2 muon beam is shown below:



<-- *Please click in the picture for a larger size image*

A more detailed description of the M2 beam layout is available in the form of a so-called Beatch listing, indicating the exact positions of all magnets, collimators and detectors. A more graphical view is provided by the optics drawings, which in addition to the positions of the numerous beam elements, show the different optical terms for the available beam modes:

Optics version	Postscript	PDF
Hadron section of **muon beam** **Muon section** of **muon beam**	X X	X X
Hadron optics, standard version	X	X
Hadron optics, compatible with P61 operation	X	X
Secondary beam section of **electron beam** **Tertiary beam section** of **electron beam**	X X	X X

2. Magnet and collimator settings, beam files

The beam transport and definition in the M2 beam is to a large extent controlled by magnets and collimators. Beam files exist for muon, hadron and electron beams. In a given mode one can change energy by loading a different beam file. When changing mode, other equipment must be set into different positions as well. This is described in section 3. Please note that reference settings and special situations at a given time are documented in the EA Wiki pages. After loading a file, please check (with magnet and collimator status) that the wanted settings have been reached correctly.

The beam can be fine tuned by changing Bend and Trim currents, e.g. from the magnet status panel. The detailed trajectory through the COMPASS detectors can only be optimized using COMPASS detectors. The beam instrumentation allows only checking the intensity with XION-2 and the entrance position into the experimental zone with MWPC-19/20. Once you are happy with the new settings, it is recommended to save them to the active beam file or to create a new beam file with a sufficiently explicit title.

Please note that Bend-6 is the momentum defining bend. Its settings shall never be modified away from the theoretical (= beam file) setting!

The most relevant steering elements are the following:

	Position	**Angle**
Horizontal:	Bend-7 or Bend-9	Trim-5 and/or Trim-6 or a linear combination, depending on the optical mode
Vertical:	Trim-7 or Bend-8	Bend-4 or Bend-5

You may find that Bends 4 and 5 are off with the message “Delested”. This means that the SM1+2 interlock has stopped these bends to protect the COMPASS detectors. This interlock is activated when SM1 or SM2 has tripped or when the COMPASS target dipole is switched on. Please correct that problem and Bends 4 and 5 should come back on automatically.

The focusing can be adapted by small adjustments of Q35 and Q36. Q35 is (in most of the modes) a horizontally focusing quadrupole, Q36 a vertically focusing one. Normally single scans of Q35 and Q36 are made to minimize the rate in some small aperture halo counter (read via an EXPT scaler) close to the nominal target position. Note that Bend-6 defines the reference momentum and it should always be kept on nominal current.

The beam flux is controlled via collimators. For the muon beam all collimators are wide open, as defined in the beam file. For the hadron and electron beam modes, reasonable settings are defined in the beam file For those beams the momentum band is defined by COLLS1+3 and COLL5 The magnetic collimators and scrapers are tuned once per year and their jaws should not be touched afterward.

3. Changes of beam mode.

The M2 beam is optimized to serve as a high-intensity muon beam. In that mode, a high flux of pions is produced in T6 and captured into a long decay section. The muons from pion decays are picked up and the pions themselves are stopped in 9 absorber modules, which MUST be present in the beam. The muons have (by definition) a lower momentum than the pions and therefore there are different central momenta defined (in the beam file) for the beam sections upstream and downstream of the absorber.

For hadron and electron beams the absorbers must be OUT of the beam. For hadrons the energy is unique all along the beam line. For electrons, a thin lead target is put into the beam to degrade the momentum of the electrons in the beam (typically -100 GeV/c) leaving T6. The part of the beam after this electron target is set to a lower momentum (e.g. -40 GeV/c) to pick up the momentum degraded electrons and transport them to the experiment.

In changing mode it is important to respect the order of operations. If not, there is a high risk of creating radiation alarms or even damaging parts of the COMPASS detectors.

- From muons to hadrons or electrons:

  First load the hadron (or electron) beam file and make sure that the collimators are closed. In case of electrons, make sure that the electron target has been moved in. Select the appropriate T6 target head (short target for high-energy positive hadron beams!). Only then the absorbers may be removed (via the Obstacle status).

- From hadrons (or electrons) to muons:

  First put all absorbers IN (from the Obstacle status) and make sure that the electron target is OUT. Only then the muon beam file shall be loaded. It is recommended to start with a short target head in T6.Only when you have verified that the beam is well steered (e.g. in MWPC 19+20) you should put the 500 mm target for optimum flux.

The settings for the different beam modes are summarized in the table below:

Beam Mode	**Typical momentum**	Safety guarantee	**T6 target head length**	**Hadron absorbers**	**Colls 1 to 5**	**Secondary Target**
Muons	+177/160	Absorbers	any OK	- I I I I I I -	Open	Out
Hadrons	+200 -100	T6 head Colls 1-5	max. 100 up to 500	- - - - - - - - -	Very closed	Out
Electrons	-100/40	Colls 1-5 p_{EHN2}/p_{T6}	**Must** be 500	- - - - - - - - -	Rather closed	In

4. Checking the setting and performance of the beam

The performance and settings of the beam line are checked by

- The General Status panel – to check all “static settings” and rates
- The MWPC profiles, in particular MWPC 19+20
- The magnet status

Please compare with reference settings and correct, if necessary. Please note that the beam intensity is only reliably measured with XION-2.

5. Final instructions and remarks

The Access Command panel allows taking or ending an access.

In case of problems, please call the SPS operators at 77500.