



Reorganization of (HL-)LHC mask

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Based on the work of:

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Outline

- **Introduction**
 - Online resources
- **How to setup a simulation**
 - The structure of the main configuration file
- **Organization of the code**
 - Overview of the modules
- **Documentation of external interfaces**
- **How to contribute to the mask**
- **Repository for the beam-beam macros**

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Introduction

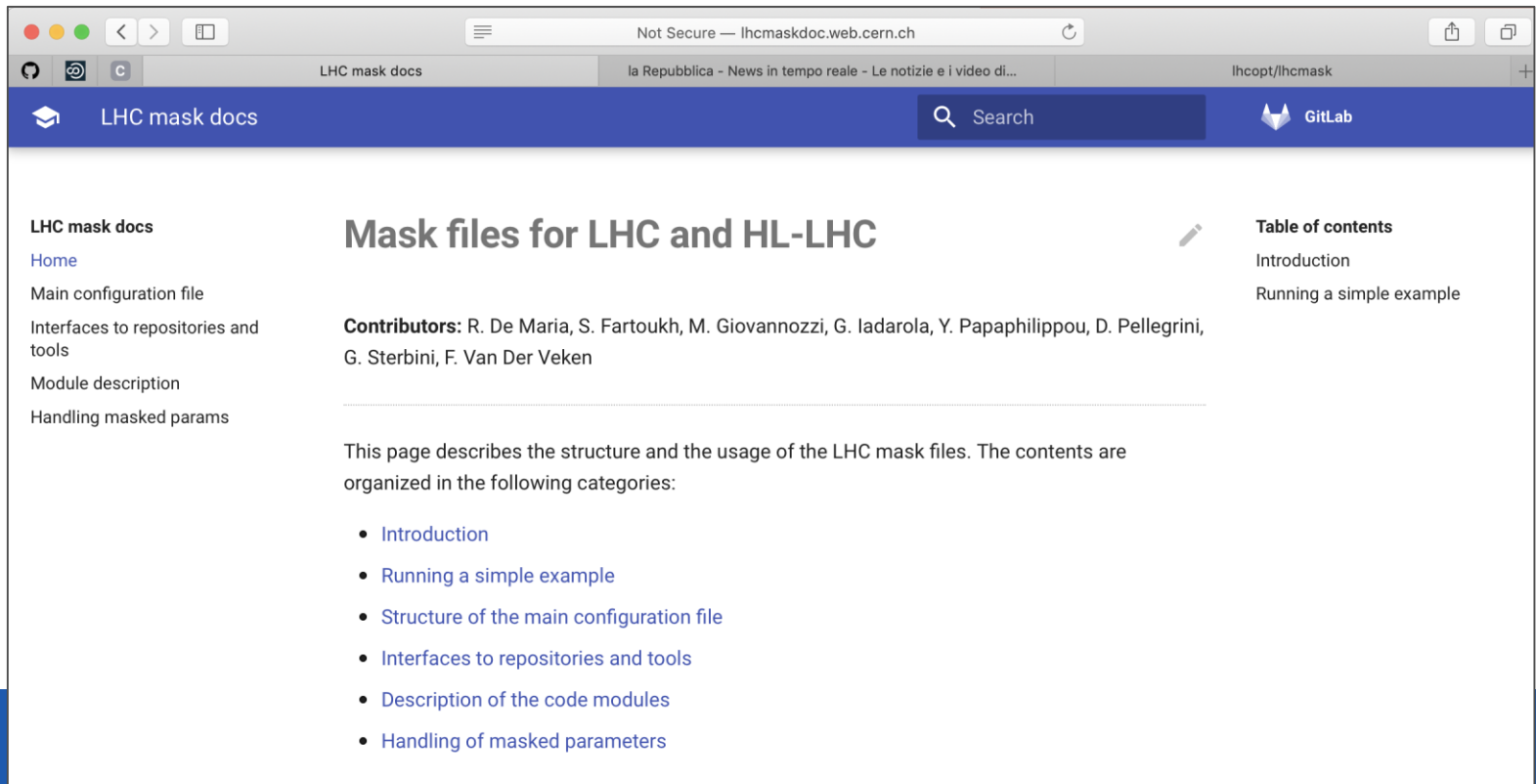
We tried to address a series of shortcomings of the present mask:

- **No central repository**, proliferation of “quasi-copies”
 - Difficult to propagate fixes of known bugs
- **Lack of documentation**
- **Monolithic structure**
 - Different **functionalities are entangled** (difficult to identify a maintainer)
 - **Interleaved settings and code**
 - **Difficult to separate general functionalities from optics-dependent** or configuration-dependent parts (LHC vs HL-LHC, injection/collision)
- **Not well-defined interface with optics** (which knobs are used).
 - Nested dependencies through macros (in madx everything is global)
- Several absolute links to different **AFS locations**

→ **Error-prone and difficult to use, develop and maintain**

Reorganized (HL-)LHC mask file

- We prepared a **reorganized version** of the LHC mask file
 - No change in the physics behavior w.r.t. a legacy reference mask (HL1.4)
 - It is **hosted** and **tracked** on **github** at: <https://github.com/lhcopt/lhcmask/>
 - It is **available on AFS** at: /afs/cern.ch/eng/lhc/optics/simulation_tools/modules
- **Documentation** is available at: <https://cern.ch/lhcmask>



The screenshot shows a web browser window displaying the 'LHC mask docs' website. The browser's address bar shows 'Not Secure — lhcmaskdoc.web.cern.ch'. The website has a blue header with the title 'LHC mask docs', a search bar, and a 'GitLab' logo. The main content area is titled 'Mask files for LHC and HL-LHC'. On the left, there is a sidebar with a 'Table of contents' section listing 'Introduction' and 'Running a simple example'. The main text area contains a 'Contributors' list: R. De Maria, S. Fartoukh, M. Giovannozzi, G. Iadarola, Y. Papaphilippou, D. Pellegrini, G. Sterbini, and F. Van Der Veken. Below this, it states: 'This page describes the structure and the usage of the LHC mask files. The contents are organized in the following categories:'. A bulleted list follows, listing: 'Introduction', 'Running a simple example', 'Structure of the main configuration file', 'Interfaces to repositories and tools', 'Description of the code modules', and 'Handling of masked parameters'.

LHC mask docs

Mask files for LHC and HL-LHC

Contributors: R. De Maria, S. Fartoukh, M. Giovannozzi, G. Iadarola, Y. Papaphilippou, D. Pellegrini, G. Sterbini, F. Van Der Veken

This page describes the structure and the usage of the LHC mask files. The contents are organized in the following categories:

- Introduction
- Running a simple example
- Structure of the main configuration file
- Interfaces to repositories and tools
- Description of the code modules
- Handling of masked parameters

Table of contents

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- Running a simple example

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How to setup a simulation

The user edits and runs a **main configuration script** (main.mask) which contains only:

- **Parameters** settings
- **Links** to folders or files (optics, errors, mask, modules)
- **Calls** to madx input files, mostly from centralized repositories

main.mask - machine and beam parameters

All in one place:

```
par_myLHCbeam = 1;

! Beam parameters
par_beam_norm_emit = 2.5E-6; ! [m]
par_beam_sigt = 0.075;      ! [m]
par_beam_sige = 1.1e-4;     ! [-]
par_beam_npart = 1.2E11;    ! [-]
par_beam_energy_tot = 7000; ! [GeV]

! Settings
par_oct_current = 300;      ! [A]
par_chromaticity = 15;      ! [-] This is the Q'
par_vrf_total = 16.;       ! [MV]

! Integer tunes and tune split
par_qx00 = 62.0;
par_qy00 = 60.0;
par_tsplitt = 2.0;

! Tunes with fractional part
par_qx0 = 62.31;
par_qy0 = 60.32;
```

```
! Dispersion correction knob
par_on_disp = 1;

! Second order chromaticity
! Correction of residual Q'' by M0's
par_on_qpp = 0;
```

```
! IP specific orbit settings
par_xing_ang_ip15 = 245;      ! [urad]
par_on_x1 = par_xing_ang_ip15; ! [urad]
par_on_sep1 = -0.75;         ! [mm]
par_on_x5 = par_xing_ang_ip15; ! [urad]
par_on_sep5 = 0.75;          ! [mm]
par_on_x2 = 170;             ! [urad]
par_on_sep2 = 1;             ! [mm]
par_on_x8 = -200;            ! [urad]
par_on_sep8 = -1;            ! [mm]
par_on_a1 = 0;               ! [urad]
par_on_o1 = 0;               ! [mm]
par_on_a5 = 0;               ! [urad]
par_on_o5 = 0;               ! [mm]
par_on_a2 = 0;               ! [urad]
par_on_o2 = 0;               ! [mm]
par_on_a8 = 0;               ! [urad]
par_on_o8 = 0;               ! [mm]
par_on_crab1 = -190;         ! [urad]
par_on_crab5 = -190;         ! [urad]
```

```
! Magnets of the experiments
par_on_alice = 7000/par_beam_energy_tot;
par_on_LHCB = 7000/par_beam_energy_tot;

par_on_sol_atlas = 0;
par_on_sol_cms = 0;
par_on_sol_alice = 0;
```

main.mask – beam-beam

```
!*****!  
! Beam-beam configuration !  
!*****!  
  
! If 1 lumi leveling in IP8 is applied  
! and q/q' match is done with bb off  
par_on_collision = 1;  
par_on_bb_switch = 1;  
  
par_b_t_dist = 25.; ! bunch separation [ns]  
  
par_n_inside_D1 = 5; ! default # of BBLR in D1  
  
par_nho_IR1 = 11;    ! # of slices for H0 in IR1  
par_nho_IR2 = 11;    ! # of slices for H0 in IR2  
par_nho_IR5 = 11;    ! # of slices for H0 in IR5  
par_nho_IR8 = 11;    ! # of slices for H0 in IR8  
  
par_install_crabcavities=1;
```

main.mask - leveling in ip8

```
!*****!  
!      Leveling in IP8      !  
!*****!  
  
! This variables set the leveled luminosity  
! in IP8 (considered if par_on_collision=1)  
par_lumi_ip8 = 2e33;    ![Hz/cm2]  
  
! These variables define the number of H0  
! collisions in the 4 IPs  
par_nco_IP1 = 2592;  
par_nco_IP5 = par_nco_IP1;  
par_nco_IP2 = 2288;  
par_nco_IP8 = 2396;
```

main.mask - errors and corrections

```
!*****!  
!  Errors and corrections  !  
!*****!  
  
! Select seed for errors  
par_myseed = %SEEDRAN;  
  
! Set this flag to correct the errors of D2  
! in the NLC  
par_correct_for_D2 = 0;  
  
! Set this flag to correct the errors of MCBXF  
! in the NLC  
par_correct_for_MCBX = 0;  
  
par_on_errors_LHC = 1;  
par_on_errors_MBH = 1;  
par_on_errors_Q5 = 1;  
par_on_errors_Q4 = 1;  
par_on_errors_D2 = 1;  
par_on_errors_D1 = 1;  
par_on_errors_IT = 1;  
par_on_errors_MCBRD = 1;  
par_on_errors_MCBXF = 1;
```

main.mask - select sources

```
!*****!  
!   Prepare environment   !  
!*****!  
  
system, "ln -fns /afs/cern.ch/eng/lhc/optics/simulation_tools simulation_tools";  
  
! Mask code folder  
system, "ln -fns simulation_tools/modules modules";  
  
! Machine folder  
system, "ln -fns simulation_tools/machines machines";  
  
! Toolkit folder  
system, "ln -fns simulation_tools/tools tools";  
  
! Beam-beam macros folder  
system, "ln -fns simulation_tools/beambeam_macros beambeam_macros";  
  
! Errors folder  
system, "ln -fns simulation_tools/errors errors";
```

main.mask – select sequence and optics

```
! Choose build-sequence script
system, "ln -fns machines/sequences/hl14_thin.madx  make_sequence.madx";

! Choose optics (magnet strengths)
system, "ln -fns /afs/cern.ch/eng/lhc/optics/HLLHCV1.4/round/\
        opt_round_150_1500_thin.madx optics.madx";
```

The **make_sequence script** (optionally user-defined):

- Should **define the sequences** complete of all their elements (including placeholders for the sequence)
- Can perform a **slicing** (makethin) and installation of additional elements (e.g. wire)
- Should **cycle the machine** to start from IP3
- Defines **links to the optics repository toolkit** and calls the corresponding macro.madx file

Predefined machine **scripts for common simulation scenarios** are available:

- In AFS at /afs/cern.ch/eng/lhc/optics/simulation_tools/machines
- On github at <https://github.com/lhcopt/lhcmachines>

main.mask - run!

The actual **execution** consist in just a set of calls:

```
! Build machine and optics
call, file="make_sequence.madx";
call, file="optics.madx";

! Call mask modules
call, file="modules/module_01_set_orbit.madx";
call, file="modules/module_02_lumilevel.madx";
call, file="modules/module_03_beambeam.madx";
call, file="modules/module_04_install_and_correct_errors.madx";
call, file="modules/module_05_machine_tuning.madx";
call, file="modules/module_06_make_sixtrack_input.madx";
call, file="modules/module_07_last_twiss.madx";

stop;
```

The modules part consists of general functionalities, which **aim at being independent from optics and machine configuration**

→ in most cases they **can be used directly from the repository** without modifications

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What are the modules doing?

The **modules are documented** at <http://lhcmaskdoc.web.cern.ch/modules/>

module_01_set_orbit.madx (main expertise: HSS)

- Defines the madx beams
- Performs a twiss for the sequences as loaded by the make_sequence script
- Applies the user-defined orbit knobs (crossing, separations, experimental magnets) and twiss again
- Save the orbit knobs
- Performs a twiss with flat orbit
- Performs a twiss with the user-defined orbit

What are the modules doing?

The **modules are documented** at <http://lhcmaskdoc.web.cern.ch/modules/>

module_02_lumilevel.madx (main expertise: HSI)

- Separates IP8 (in the horizontal plane) to achieve the target luminosity.
- Run the final crossing_save (overwrites save state of IP knobs)

module_03_beambeam.madx (main expertise: HSI)

- Forces on_disp=0
- Configures and installs the beam-beam lenses
- Generates bb_lenses.dat (to be replaced in the sixtrack input)
- Installs the the crab cavities (if enabled)
- NB: the beam-beam kicks are kept disabled (can be enabled by setting on_bb_charge = 1)

What are the modules doing?

The **modules are documented** at <http://lhcmaskdoc.web.cern.ch/modules/>

module_04_install_and_correct_errors.madx (main expertise: HSS)

- Loads the error tables and applies field-imperfections
- Introduces misalignments
- Applies corrections

module_05_machine_tuning.madx (main expertise: HSS)

- Restores the crossing knobs as saved by module_01_set_orbit or module_02_lumilevel (using crossing_save)
- Power the octupoles as defined by the user
- Matches orbit, tunes and chromaticity
- Corrects the linear coupling
- Clips corrector strengths to maximum allowed
- Switches on the beam-beam lenses (on_bb_charge = 1)
- Introduces RF voltage and lags.

What are the modules doing?

The **modules** are **documented** at <http://lhcmaskdoc.web.cern.ch/modules/>

module_06_make_sixtrack_input.madx (main expertise: HSS-HSI)

- Produces sixtrack input (call sixtrack command of madx)
- If beam-beam is enabled, inserts data or beam-beam lenses from bb_lenses.dat into fc.3

module_07_last_twiss.madx (main expertise: HSS-HSI)

- Performs a twiss on the last machine configuration.

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Documentation of external interfaces

- The mask relies on **naming** (and **unit**) **conventions** to interact with the optics and toolkits.
- We started identifying the **status of the present interface** by populating a webpage: <http://lhcmaskdoc.web.cern.ch/interfaces/>
- In the future we should aim at **standardizing this nomenclature** as much as possible

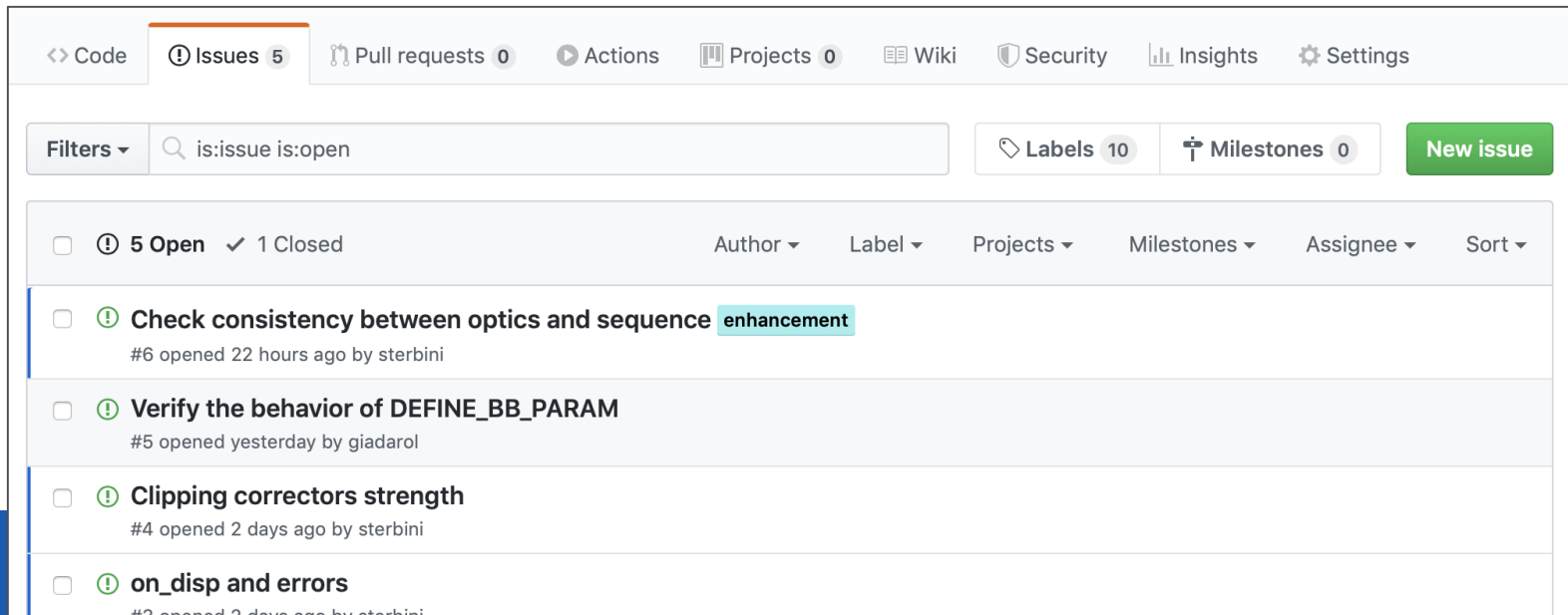
The screenshot displays the 'LHC mask docs' website. The header includes the site name, a search bar, and a GitLab logo. A left sidebar lists navigation links: Home, Main configuration file, Interfaces to repositories and tools (highlighted), Module description, and Handling masked params. The main content area is titled 'Interfaces to repositories and tools' and contains the following text: 'The module use the following variables and macros (the list is still not complete!). Please verify that your optics respects the same naming convention:'. Below this, under the heading 'Optics related:', there is a list of variables: on_x1, on_sep1, on_x5, on_sep5, on_x2, on_sep2, on_x8, on_sep8, on_a1, on_o1, on_a5, on_o5, on_a2, on_o2, and on_o8. A right sidebar titled 'Table of contents' lists 'Optics related:', 'Beam-beam related', and 'Error related'.

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Contributing to the mask

- We will keep an **updated version** of the masks in **AFS** and on **github**
 - We are using github to track issues (bugs, proposals, questions)
- You are very **welcome to contribute** with fixes, improvements, new features, documentation, examples.
 - It's **very important to merge into the main version** new features that are of general interest to avoid proliferation of branches:
 - The preferred way is to use github (fork/pull-request)
 - If you don't use github, just ask one of the maintainers for the merge



The screenshot displays the GitHub interface for the 'mask' repository. At the top, navigation tabs include 'Code', 'Issues' (5), 'Pull requests' (0), 'Actions', 'Projects' (0), 'Wiki', 'Security', 'Insights', and 'Settings'. Below the tabs, there's a 'Filters' dropdown, a search bar containing 'is:issue is:open', and buttons for 'Labels' (10) and 'Milestones' (0). A green 'New issue' button is on the right. The main content area shows a list of 5 open issues. Each issue has a checkbox, a green circle with an exclamation mark, a title, a label, and a description. The first issue is 'Check consistency between optics and sequence' with a label 'enhancement'. The second issue is 'Verify the behavior of DEFINE_BB_PARAM'. The third issue is 'Clipping correctors strength'. The fourth issue is 'on_disp and errors'. The fifth issue is partially visible.

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	5 Open	1 Closed	Author	Label	Projects	Milestones	Assignee	Sort	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Beam beam macros

- The **beam-beam macros** are hosted and tracked on a dedicated **github** repository: https://github.com/lhcopt/beambeam_macros
- Same development approach → contributions are welcome!

lhcopt / **beambeam_macros** Unwatch 3 Star 0 Fork 1

<> Code Issues 9 Pull requests 0 Actions Projects 0 Wiki Security Insights Settings

Beam beam macros to setup tracking simulations Edit

Manage topics

37 commits 2 branches 0 packages 1 release 2 contributors

Branch: master New pull request Create new file Upload files Find file Clone or download

giadarol Status		Latest commit 0ee4ec4 19 hours ago
additional_tools	Merge branch 'branch_guido'	3 months ago
examples	Rename	3 months ago
.gitignore	Adding crossing plane tests	4 months ago
fillfoottable.f	First commit	8 months ago
headonslice.f	First commit	8 months ago
macro_bb.madx	Status	19 hours ago
macro_bb.md	Test md file	4 months ago
makefile	End of the 32bit era	8 months ago
meld.txt	Minor formatting	4 months ago

Summary

- We reorganized the (HL-)LHC mask file
- Main features:
 - Separated input from code
 - Code divided in functional modules
 - Isolate as much as possible general code from optics-dependent parts
- The modules are hosted online and on AFS
 - Examples are provided
- A documentation website has been built (please contribute to enrich it!)
- Please try it out
 - Caveat: never use it as a black box, sanity checks are important!
- Please contribute with feedback and improvements (that you might already have)!

Thanks for you attention!

Spare: handling masked parameters

For large scans some of the parameters in the main.mask ion script can be replaced by symbols that will be set by sixdesk

```
! Beam parameters
par_beam_norm_emit = %EMIT_BEAM;      ! [m]
par_beam_sigt = 0.075;                 ! [m]
par_beam_sige = 1.1e-4;                ! [-]
par_beam_npart = %NPART;               ! [-]
par_beam_energy_tot = 7000;            ! [GeV]

! Settings
par_oct_current = %OCT%;                ! [A]
par_chromaticity = %CHROM%;             ! [-] This is the Q'
par_vrf_total = 16.;                   ! [MV]
```

An input containing masked parameters cannot be executed directly with madx

We made a little tool to quickly unmask (and optionally run your script)

```
python unmask.py main.mask parameters_for_unmask.txt
madx main.mask.unmasked
```

Spare: an example of build-sequence

```
! Specify machine version (used by errors)
ver_lhc_run = 0; ver_hllhc_optics = 1.4;

! Get the toolkit
call, file="/afs/cern.ch/eng/lhc/optics/HLLHCV1.4/toolkit/macro.madx";

! Build sequence
if (mylhcbbeam==4){
  call, file="/afs/cern.ch/eng/lhc/optics/runIII/lhcb4.seq";
} else {
  call, file="/afs/cern.ch/eng/lhc/optics/runIII/lhc.seq";};

!Install HL-LHC
call, file="/afs/cern.ch/eng/lhc/optics/HLLHCV1.4/hllhc_sequence.madx";

! Slice nominal sequence
exec, myslice;

! Install placeholder elements for errors (set to zero)
call, file="errors/HL-LHC/install_MQXF_fringenl.madx";
call, file="errors/HL-LHC/install_MCBXFAB_errors.madx";
call, file="errors/HL-LHC/install_MCBRD_errors.madx";

!Cycling w.r.t. to IP3
if (mylhcbbeam<3){
  seqedit, sequence=lhcb1; flatten; cycle, start=IP3; flatten; endedit;}
  seqedit, sequence=lhcb2; flatten; cycle, start=IP3; flatten; endedit;
```