



# The NLOAccess project

**Carlo Flore**

Université Paris-Saclay, CNRS, IJCLab Orsay

**Progress in algorithms and numerical tools for QCD**

**07 Jun 2022**

# The NLOAccess framework

The STRONG-2020 WP **VA1-NLOAccess**:

- a **virtual access** for automated perturbative calculation for heavy ions and quarkonia
- **automation** and **versatility**:
  - everyone would be able to evaluate physical observables related to hadron scatterings
  - no need to pre-code
  - test the code
- any code that could be compiled and launched via bash could be added
- ✓ HELAC-Onia and MadGraph5 (MG5\_aMC@NLO) are included

# HELAC-Onia (I)

H.-S. Shao, CPC 184 (2013) 2562-2570 & CPC 198 (2016) 238-259

HELAC-Onia is an automatic matrix element and event generator for quarkonium physics

- based on NRQCD framework
- based on off-shell recursion relations

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HELAC-Onia is an automatic matrix element and event generator for quarkonium physics

- based on **NRQCD** framework
- based on **off-shell recursion relations**

NRQCD factorisation:

$$\sigma(pp \rightarrow Q + X) = \sum_{i,j,n} \int dx_1 dx_2 f_{i/p}(x_1) f_{j/p}(x_2) \hat{\sigma}(ij \rightarrow Q\bar{Q}[n] + X) \langle \mathcal{O}_n^Q \rangle$$

- $f_{i/p}(x_1), f_{j/p}(x_2)$  are the **PDFs**
- $\hat{\sigma}(ij \rightarrow Q\bar{Q}[n] + X)$  is the **partonic cross section** for producing a heavy quark pair in the Fock state  $n$
- $n = {}^{2S+1}L_J^c$ , with  $c = 1, 8$  (color singlet or color octet)
- $\langle \mathcal{O}_n^Q \rangle$  are the **LDMEs**

## Main features:

- **Standard Model** calculations but BSM extension is feasible
- different kind of calculation: multiple quarkonia production, event generation, yields vs polarisation, angular distributions of quarkonia decays...
- reweighting method for estimating renormalisation/factorisation scale and PDF uncertainties
- interface with **LHAPDF**
- interface with **PYTHIA 8, QEDPS**

*MadGraph5\_aMC@NLO is a framework that aims at providing all the elements necessary for SM and BSM phenomenology, such as the **computations of cross sections**, the **generation of hard events and their matching with event generators**, and the use of a variety of tools relevant to event manipulation and analysis. Processes can be simulated to **LO accuracy for any user-defined Lagrangian**, and at the **NLO accuracy** in the case of models that support this kind of calculations – prominent among these are QCD and EW corrections to SM processes. **Matrix elements at the tree- and one-loop-level** can also be obtained.*

# Interlude - code vs metacode

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What is the main difference between HELAC-Onia and MG5\_aMC@NLO?

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HELAC-Onia is a **code**



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MG5\_aMC@NLO is a **metacode**, *i.e.* a code generating another code

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HELAC-Onia is a **code**

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	HELAC-Onia	MG5_aMC@NLO
compilation	once	once for each generate command
running	run single executable each time	(re-)run the generated code for the requested process
code re-usage	✗	✓

# NLOAccess - facts and figures

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Some facts and figures about NLOAccess:

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  - **live user run status** and **run history**
  - almost **zero computational cost** for the users
  - guided input file creation and submission for H0:  
[https://nloaccess.in2p3.fr/H0/downloads/H0\\_online\\_guide\\_v01.pdf](https://nloaccess.in2p3.fr/H0/downloads/H0_online_guide_v01.pdf)

# NLOAccess - Homepage

(<https://nloaccess.in2p3.fr>)

**NLOAccess**  
Virtual Access: Automated perturbative NLO calculations for heavy ions and quarkonia (NLOAccess)

Home - The project - Communication - Tools - Account - Downloads - Request registration

### GENERAL DESCRIPTION

**Objectives:**

NLOAccess will give access to automated tools generating scientific codes allowing anyone to evaluate observables - such as production rates or kinematical properties - of scatterings involving hadrons. The automation and the versatility of these tools are such that these scatterings need not to be pre-coded. In other terms, it is possible that a random user may request for the first time the generation of a code to compute characteristics of a reaction which nobody thought of before. NLOAccess will allow the user to test the code and then to download to run it on its own computer. It essentially gives access to a dynamical library.

The automated tools on which NLOAccess is based are (i) the MADGRAPH ensemble heavily used by the high-energy physics (HEP) community, but extended to deal with meson and heavy-ion beams and (ii) the HELAC-ONIA code allowing the computation of cross section for heavy-quark bound states, the quarkonia.

The portal NLOAccess will allow one to access additional automated tools. I will extend the portal of MADGRAPH@UCLouvain with the necessary additions to deal with heavy-ion collisions and quarkonium production.

As of today, in contrast to HEP, no such place exists for hadronic physics where interested colleagues can go test their ideas and turn them into concrete realisation with automated Monte Carlo tools. In addition, the available tools are limited to a reduced class of applications. For each, one needs to install them one by one, sometimes along with dedicated libraries and one needs to get familiar with their syntax. A single portal for hadron physics will not only ease the task of the

### FOLLOW:

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This e-infrastructure is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 624093.

SEARCH:

### RECENT POSTS

© Jean-Philippe Lansberg gives a talk at

7 TeV LHC Color Singlet  $2 < \chi_{\text{min}} < 4.5$   $\chi_{\text{min}}^2/m_c^2 = 4$

$d\sigma/dP_T$  (nb/GeV)

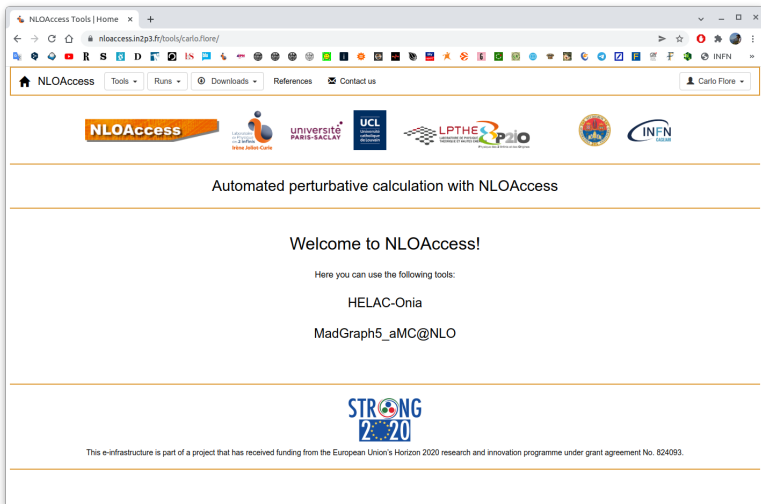
$10^1$   
 $10^0$   
 $10^{-1}$   
 $10^{-2}$   
 $10^{-3}$   
 $10^{-4}$   
 $10^{-5}$   
 $10^{-6}$   
 $10^{-7}$   
 $10^{-8}$   
 $10^{-9}$   
 $10^{-10}$

10 20 25 30

<https://nloaccess.in2p3.fr>

# NLOAccess Tools - Homepage

(<https://nloaccess.in2p3.fr/tools/>)



The screenshot shows a web browser window with the address bar displaying `nloaccess.in2p3.fr/tools/carlo.flore/`. The page features a navigation menu with 'Tools', 'Runs', 'Downloads', 'References', and 'Contact us'. Below the menu is a row of logos for NLOAccess, Université Paris-Saclay, UCL, LPTHE, and INFN. The main content area contains the text 'Automated perturbative calculation with NLOAccess', 'Welcome to NLOAccess!', and a list of tools: 'HELAC-Onia' and 'MadGraph5\_aMC@NLO'. At the bottom, there is a 'STRONG 2020' logo and a note about funding from the European Union's Horizon 2020 programme.

NLOAccess Tools | Home x +

nloaccess.in2p3.fr/tools/carlo.flore/

NLOAccess Tools Runs Downloads References Contact us Carlo Flore

NLOAccess Université Paris-Saclay UCL LPTHE INFN

Automated perturbative calculation with NLOAccess

Welcome to NLOAccess!

Here you can use the following tools:

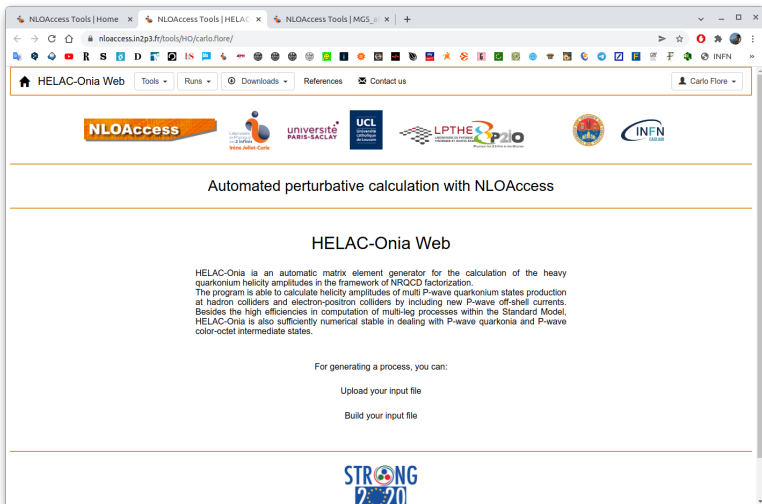
- HELAC-Onia
- MadGraph5\_aMC@NLO

STRONG 2020

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# HELAC-Onia Web - Homepage

(<https://nloaccess.in2p3.fr/H0/>)



The screenshot shows a web browser window with the URL `nloaccess.in2p3.fr/tools/H0/carlo.flore/`. The page features a navigation bar with "HELAC-Onia Web", "Tools", "Runs", "Downloads", "References", and "Contact us". Below the navigation bar is a row of logos for NLOAccess, Laboratoire de Physique des Hautes Energies (HEP) at Université Paris-Saclay, UCL, LPTHE, P2IO, and INFN. The main content area is titled "Automated perturbative calculation with NLOAccess" and "HELAC-Onia Web". A paragraph describes the program as an automatic matrix element generator for heavy quarkonium helicity amplitudes. Below this, it lists options for generating a process: "Upload your input file" and "Build your input file". At the bottom, there is a logo for STRONG-2020.

# HELAC-Onia Web - Run submission

The screenshot shows a web browser window with the URL `nlaccess.in2p3.fr/tools/HO/carlo.flore/guided-file-submission/`. The page title is "HELAC-Onia - Guided input file submission". The interface includes a navigation bar with "Tools", "Runs", "Downloads", "References", and "Contact us" links, and a user profile for "Carlo Flore".

The main content area is titled "Create your input file" and contains the following elements:

- A text prompt: "Edit here your input file:"
- A section labeled "Input next command(s):" with a large empty text box and an "Add command(s)" button below it.
- A section labeled "Remove line(s) containing:" with an empty input field, "Remove line(s)" and "Clear file" buttons, and a "Submit job" button.
- A section labeled "Your input file:" containing a code block with the following content:

```
generate p > cc-(3S11) cc-(3S11)
set colpar = 1
set energy_beam1 = 7000
set energy_beam2 = 7000
set qcd = 2
decay cc-(3S11) > m+ m- @ 0.06
launch
```
- A text prompt: "Please, remember to follow this structure for your input file:"
- A code block showing the required structure:

```
generate { process }
set { parameter } = { value }
:
:
launch
```
- A note: "For more examples: see this reference or take a look to the [User Guide](#)."



# HELAC-Onia Web - Run submission

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set energy_beam1 = 7000
set energy_beam2 = 7000
set qcd = 2
decay cc~(3S11) > m+ m- @ 0.06
launch
```

Below the code editor, there are several interactive elements:

- An "Add command(s)" button.
- A "Remove line(s) containing:" input field.
- "Remove line(s)" and "Clear file" buttons.
- A "Submit job" button.

To the right of the code editor, there is a note: "Please, remember to follow this structure for your input file:" followed by a code block showing the required structure:

```
generate { process }
set { parameter } = { value }
:
launch
```

At the bottom right, there is a reference: "For more examples: see this reference or take a look to the [User Guide](#)."

# HELAC-Onia Web - Input file

The input file should be in the following form:

```
generate { process }  
set { parameter }={ value }  
  
:  
launch
```

Users can have control on several kind of parameters via the set command:

- collisions parameters;
- theory parameters;
- MC setup variables;
- PDFs parameters;
- kinematical cuts;
- quarkonium specific parameters (e.g. the values of different LDMEs);
- physical constants (both EW and QCD sectors, e.g.  $M_Z$  or  $M_W$ , or  $m_q$ , or couplings).
- kind of output (ROOT, Gnuplot, TopDrawer or LHE)

# HELAC-Onia Web - Results (I)

The screenshot shows an email client window with the following details:

- Subject:** [nloaccess][HELAC-Onia] Your new results from HELAC-Onia Web - Posta in arrivo - carlo.flore@ijclab.in2p3...
- Sender:** noreply@ijclab.in2p3.fr
- Recipient:** Me <carlo.flore@ijclab.in2p3.fr>
- Time:** 12:04
- Body:**

Dear Carlo,

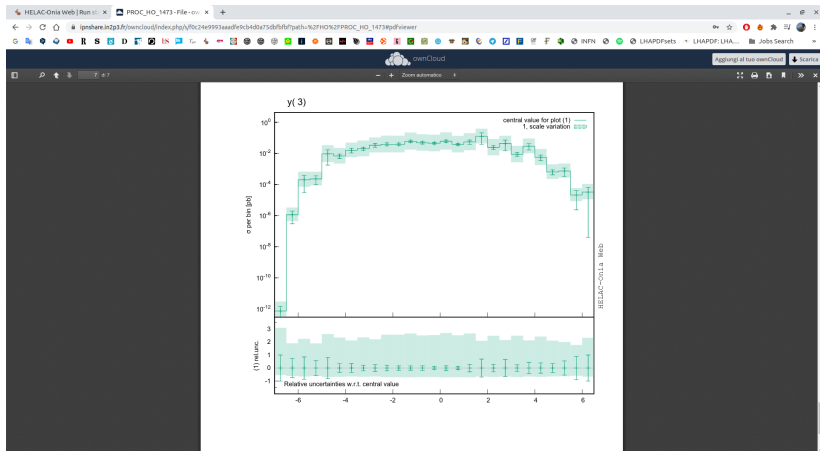
your latest results are now stored in your [OwnCloud folder](#). You can find them in the subdirectory /HO/PROC\_HO\_3011.

Best regards,

--

The NLOAccess Team

# HELAC-Onia Web - Results (II)



- MadGraph5 online version was only limited to LO calculation
- NLOAccess offers access **for the first time to full NLO SM online calculation** with **MG5\_aMC@NLO!**



The screenshot shows a web browser window with the URL `nloaccess.in2p3.fr/tools/MG5/carlo/fore/`. The page features a navigation bar with a home icon, the text "MG5\_aMC@NLO", and buttons for "Tools", "Runs", "Downloads", "References", and "Contact us". Below the navigation bar is a row of logos for NLOAccess, Université Paris-Saclay, UCL, LPTHE SP2IO, and INFN. The main content area has the heading "Automated perturbative calculation with NLOAccess" and "MG5\_aMC@NLO". A paragraph describes the framework's capabilities: "MadGraph5\_aMC@NLO is a framework that aims at providing all the elements necessary for SM and BSM phenomenology, such as the computations of cross sections, the generation of hard events and their matching with event generators, and the use of a variety of tools relevant to event manipulation and analysis. Processes can be simulated to LO accuracy for any user-defined Lagrangian, an the NLO accuracy in the case of models that support this kind of calculations – prominent among these are QCD and EW corrections to SM processes. Matrix elements at the tree- and one-loop-level can also be obtained." Below this text are two links: "Here is what you can do:", "Generate a new code", and "Check your code database". At the bottom of the page is the "STRONG 2020" logo.

# MG5\_aMC@NLO - code generation

The screenshot shows a web browser window with the URL `nloaccess.in2p3.fr/tools/MG5carlo.flore/generate-process/`. The page header includes the NLOAccess logo and logos for partner institutions: universit  PARIS-SACLAY, UCL, LPTHE SP20, and INFN. The main heading is "MG5\_aMC@NLO - Generate process".

The main content area is titled "MG5\_aMC code generation" and contains the following instructions and form:

Submit here your process and, if desired, the name of your output folder.

**import model**   
**generate**   
**output**

Or, if you want to upload your input file, do it here:

**Choose your file:**  Nessun file selezionato

• Input file syntax example (e.g.: proton proton --> t t-):

```
generate p p > t t-  
output _myoutputfolder
```

# MG5\_aMC@NLO - code database

The screenshot shows a web browser window with the URL `nloaccess.in2p3.fr/tools/MG5/carlo.flore/run-database/`. The page features a navigation bar with 'NLOAccess', 'Tools', 'Runs', 'Downloads', 'References', and 'Contact us'. Below the navigation bar are logos for NLOAccess, Université Paris-Saclay, UCL, LPTHE, and INFN. The main heading is 'MG5\_aMC@NLO - Carlo's database'. A 'Process Database' table is displayed with the following data:

Folder name	Creation date (dd/mm/yyyy)	Creation time	Process	
lest-ag2bbbar-10-11-21	10/11/2021	11:12:52	$a g > b b^-$	<a href="#">Run</a>
PROCNLO_loop_sm_20	24/09/2021	14:10:16	$p p > t t^- [QCD]$	<a href="#">Run</a>
PROC_loop_sm_1	30/09/2021	16:44:07	$p p > H [QCD]$	<a href="#">Run</a>
PROC_loop_sm_0	29/09/2021	23:10:21	$p p > h [QCD]$	<a href="#">Run</a>
PROCNLO_loop_sm_19	24/09/2021	13:04:48	$p p > t t^- [QCD]$	<a href="#">Run</a>

Below the table, it says 'Your personal OwnCloud folder'. At the bottom of the page is the CERN logo.

# MG5\_aMC@NLO - code running

The screenshot shows a web browser window with the URL `nloaccess.in2p3.fr/tools/carlo.flore/MG5/PROCNLO_loop_sm_20/run/`. The page features a navigation bar with "NLOAccess", "Tools", "Runs", "Downloads", "References", and "Contact us". Below the navigation bar are logos for NLOAccess, universit  Paris-Saclay, UCL, LPTHE, and INFN. The main heading is "MG5\_aMC@NLO - PROCNLO\_loop\_sm\_20". A "Run the process" panel contains the following configuration options:

Run the process

If needed, upload here your cards (as multiple .dat files or as a single tar.gz/zip file):

Upload cards:  Nessun file selezionato

<b>Order</b>	<input type="text" value="NLO"/>	<b>Fixed Order</b>	<input type="text" value="OFF"/>
<b>Shower</b>	<input type="text" value="No shower"/>	<b>Madspin</b>	<input type="text" value="OFF"/>
<b>Reweight</b>	<input type="text" value="OFF"/>	<b>MadAnalysis</b>	<input type="text" value="OFF"/>



# NLOAccess - Run status

Run status

Run id(s)  [Remove run\(s\)](#)

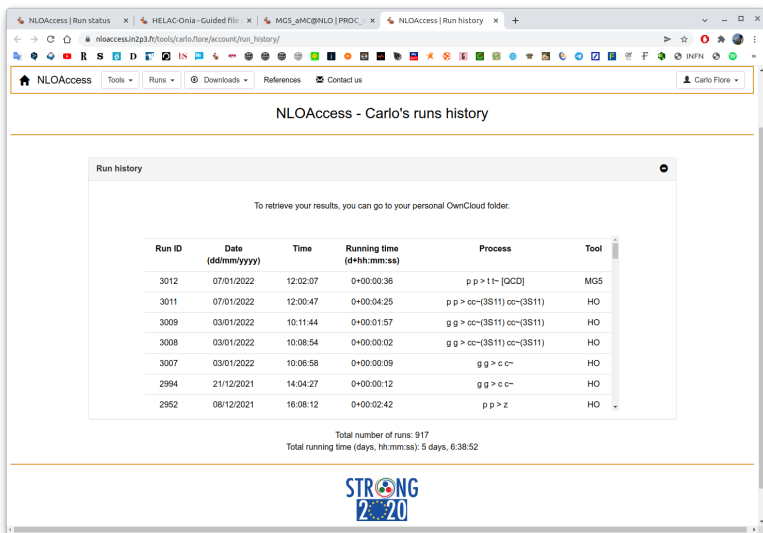
For removing multiple runs, separate the IDs with a comma or a semicolon.

Run ID	Date (dd/mm/yyyy)	Time (d+hh:mm:ss)	Idle	Running	Completed	Process	Tool
3012	07/01/2022	12:02:07	5	0	0	p p > t1+ [QCD]	MG5
3011	07/01/2022	12:00:47	0	1	6	p p > cc~(3S11) cc~(3S11)	HO

This page will automatically refresh every 30 seconds. If you want to refresh now the page, click on the button below.

[Refresh](#)

# NLOAccess - Run history



The screenshot shows a web browser window with the URL `nloaccess.in2p3.fr/tools/carlo.flore/account/run_history/`. The page title is "NLOAccess - Carlo's runs history". Below the title, there is a "Run history" section with a message: "To retrieve your results, you can go to your personal OwnCloud folder." Below this message is a table with the following data:

Run ID	Date (dd/mm/yyyy)	Time	Running time (d+hh:mm:ss)	Process	Tool
3012	07/01/2022	12:02:07	0+00:00:36	p p > t1- [QCD]	MG5
3011	07/01/2022	12:00:47	0+00:04:25	p p > cc-(3S11) cc-(3S11)	HO
3009	03/01/2022	10:11:44	0+00:01:57	g g > cc-(3S11) cc-(3S11)	HO
3008	03/01/2022	10:08:54	0+00:00:02	g g > cc-(3S11) cc-(3S11)	HO
3007	03/01/2022	10:06:58	0+00:00:09	g g > c c~	HO
2994	21/12/2021	14:04:27	0+00:00:12	g g > c c~	HO
2952	08/12/2021	16:08:12	0+00:02:42	p p > z	HO

Below the table, the following summary statistics are displayed:

- Total number of runs: 917
- Total running time (days, hh:mm:ss): 5 days, 6:38:52

At the bottom of the page, there is a logo for "STRONG 2020" featuring the European Union flag.

# NLOAccess - What's next?

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extension to *eh* collisions

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- inclusion of spin and transverse momentum effects in HELAC-Onia

- inclusion of other codes

[**suggestions are welcome!**]

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**Thank you**