



# NLOAccess: online event generators

**Carlo Flore**

Université Paris-Saclay, CNRS, IJCLab Orsay

**Quarkonium Working Group 2022**  
**28 Sep 2022**

# NLOAccess - the framework

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

- a **virtual access** for automated perturbative calculation for heavy ions and quarkonia
- an online code library
- any code that could be compiled and launched via bash could be added
- ✓ **HELAC-Onia** and **MadGraph5** (MG5\_aMC@NLO) are included

# NLOAccess - the tools

- HELAC-Onia

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

- **LO(+PS)** automated event generator for **quarkonia** in the SM
- based on the **NRQCD** framework, relies on **off-shell recursion relations**
- approximate NLO calculation (e.g. NLO\*, aNLO) feasible

C. Flore et al., Phys. Lett. B 811 (2020) 135926; H.-S. Shao, JHEP 01 (2019) 112

- MG5\_aMC@NLO

[http://amcatnlo.web.cern.ch/amcatnlo/list\\_refs.htm](http://amcatnlo.web.cern.ch/amcatnlo/list_refs.htm)

- **full NLO(+PS)** matrix element and event generator in the SM and for BSM phenomenology
- **LO for any user-defined Lagrangian**, and at the **NLO** for models supporting such a calculation
- onium feasible within **(I)CEM**

J.-P. Lansberg et al., Phys. Lett. B 807 (2020) 135559

# NLOAccess - the tools

- HELAC-Onia

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

- **LO(+PS)** automated event generator for **quarkonia** in the SM
- based on the **NRQCD** framework, relies on **off-shell recursion relations**
- approximate NLO calculation (e.g. NLO\*, aNLO) feasible

C. Flore et al., Phys. Lett. B 811 (2020) 135926; H.-S. Shao, JHEP 01 (2019) 112

- MG5\_aMC@NLO

[http://amcatnlo.web.cern.ch/amcatnlo/list\\_refs.htm](http://amcatnlo.web.cern.ch/amcatnlo/list_refs.htm)

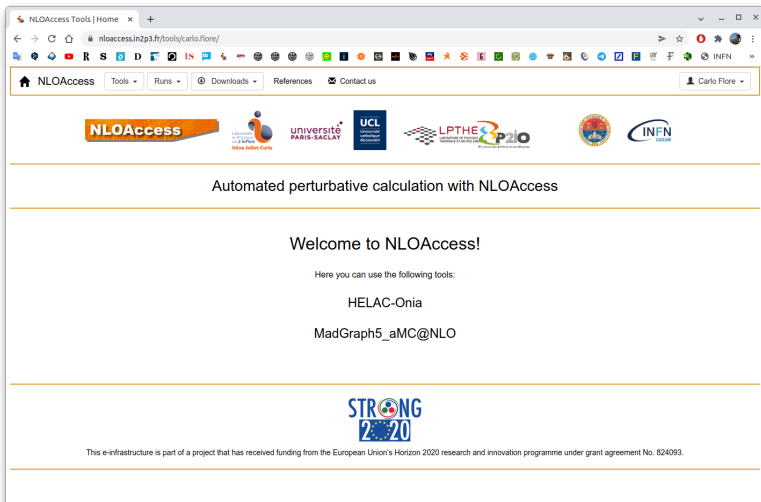
- **full NLO(+PS)** matrix element and event generator in the SM and for BSM phenomenology
- **LO for any user-defined Lagrangian**, and at the **NLO** for models supporting such a calculation
- onium feasible within **(I)CEM**

J.-P. Lansberg et al., Phys. Lett. B 807 (2020) 135559

⇒ **Les Houches Events** available for both codes

# NLOAccess Tools - homepage

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



The screenshot shows a web browser window with the address bar containing `nloaccess.in2p3.fr/tools/carlo.flore/`. The page features a navigation bar with 'NLOAccess', 'Tools', 'Runs', 'Downloads', 'References', and 'Contact us'. Below the navigation bar is a row of logos for NLOAccess, Université Paris-Saclay, UCL, LPTHE, and INFN. The main content area includes 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

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. 824093.

NLOAccess Tools | Home x NLOAccess Tools | HELAC x NLOAccess Tools | MGS x +

nloaccess.in2p3.fr/tools/H0/carlo.flore/

HELAC-Onia Web Tools Runs Downloads References Contact us Carlo Flore

NLOAccess Université Paris-Saclay UCL LPTHE Saclay INFN

Automated perturbative calculation with NLOAccess

## HELAC-Onia Web

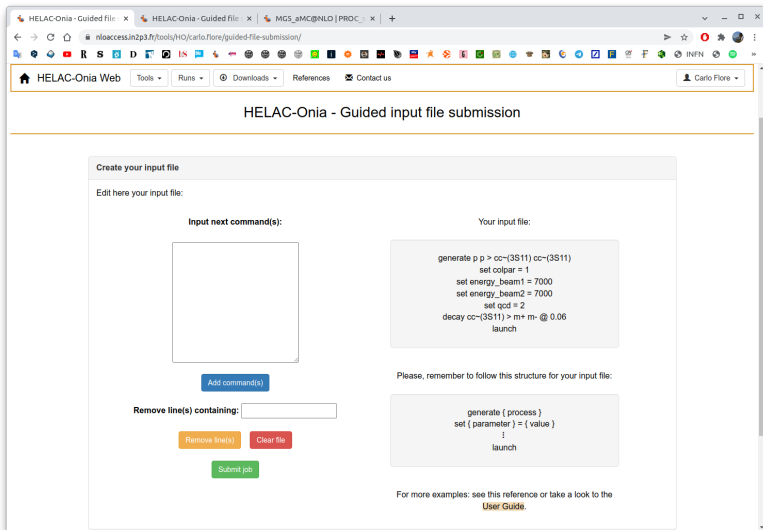
HELAC-Onia is an automatic matrix element generator for the calculation of the heavy quarkonium helicity amplitudes in the framework of NRvC0 factorization. The program is able to calculate helicity amplitudes of multi P-wave quarkonium states production at hadron colliders and electron-positron colliders by including new P-wave off-shell currents. Besides the high efficiencies in computation of multi-leg processes within the Standard Model, HELAC-Onia is also sufficiently numerical stable in dealing with P-wave quarkonia and P-wave color-octet intermediate states.

For generating a process, you can:

- Upload your input file
- Build your input file

STRONG 2020

# HELAC-Onia Web - run submission



The screenshot shows a web browser window with the URL `nloaccess.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:

- Edit here your input file:** A section with two columns.
- Input next command(s):** A large empty text area for entering commands.
- Your input file:** A preview box containing the following code:

```
generate p 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
```
- Please, remember to follow this structure for your input file:** A box showing the required structure:

```
generate { process }
set { parameter } = { value }
:
:
launch
```
- Remove line(s) containing:** A text input field for filtering lines.
- Buttons:** "Add command(s)", "Remove line(s)", "Clear file", and "Submit job".
- Footer:** A note: "For more examples: see this reference or take a look to the [User Guide](#)."

# HELAC-Onia Web - run submission

The screenshot shows a web browser window with the URL `nloaccess.in2p3.fr/tools/HO/carlo.flore/guided-file-submission/`. The page title is "HELAC-Onia - Guided input file submission". The main content area is titled "Create your input" and contains a text editor with the following code:

```
generate p 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
```

Below the text editor, there are several interactive elements:

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

To the right of the text 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

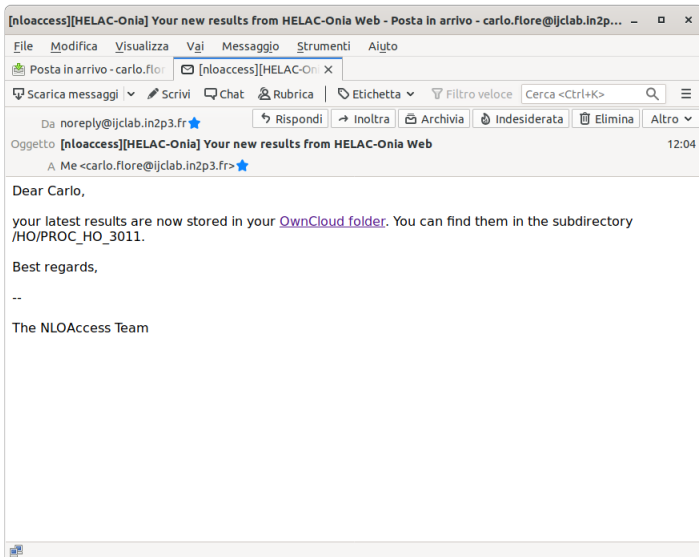
The input file should be in the following form:

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

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

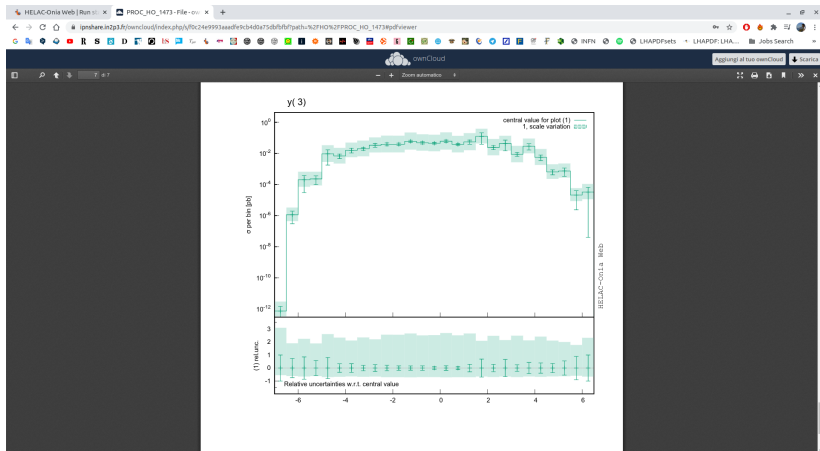
- collisions parameters;
- theory parameters;
- MC setup variables;
- PDFs parameters;
- kinematical cuts;
- quarkonium specific parameters (e.g. the values of different LDMEs);
- physical constants (both EW and QCD sectors, e.g.  $M_Z$  or  $M_W$ , or  $m_q$ , or couplings).
- kind of output (ROOT,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

# HELAC-Onia Web - results (I)



The screenshot shows an email client interface. The window title is "[nloaccess][HELAC-Onia] Your new results from HELAC-Onia Web - Posta in arrivo - carlo.flore@ijclab.in2p3...". The menu bar includes File, Modifica, Visualizza, Vai, Messaggio, Strumenti, and Aiuto. The address bar shows "Posta in arrivo - carlo.flor" and "[nloaccess][HELAC-Oni X". The toolbar contains "Scarica messaggi", "Scrivi", "Chat", "Rubrica", "Etichetta", "Filtro veloce", and a search box with "Cerca <Ctrl+K>". The email header shows it is from "noreply@ijclab.in2p3.fr" with actions like "Rispondi", "Inoltra", "Archivia", "Indesiderata", "Elimina", and "Altro". The subject is "[nloaccess][HELAC-Onia] Your new results from HELAC-Onia Web" and the time is 12:04. The sender is "Me <carlo.flore@ijclab.in2p3.fr>". The body of the email reads: "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.Flore/`. The page features a navigation bar with "MG5\_aMC@NLO" and a user profile "Carlo Flore". Below the navigation bar are logos for NLOAccess, Université Paris-Saclay, UCL, LPTHE, P2IO, and INFN. The main content area is titled "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/MG5carlofiore/generate-process/`. The page header includes the NLOAccess logo and logos for partner institutions: universit  PARIS-SACLAY, UCL, LPTHE SP2O, 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 --> tt--):

```
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	$ag > b b^-$	<a href="#">Run</a>
PROCNLO_loop_sm_20	24/09/2021	14:10:16	$pp > t\bar{t} [QCD]$	<a href="#">Run</a>
PROC_loop_sm_1	30/09/2021	16:44:07	$pp > H [QCD]$	<a href="#">Run</a>
PROC_loop_sm_0	29/09/2021	23:10:21	$pp > h [QCD]$	<a href="#">Run</a>
PROCNLO_loop_sm_19	24/09/2021	13:04:48	$pp > t\bar{t} [QCD]$	<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 header includes the NLOAccess logo and navigation menus. Below the header, there are logos for partner institutions: NLOAccess, Université Paris-Saclay, UCL, LPTHE SP20, and INFN. The main heading is `MG5_aMC@NLO - PROCNLO_loop_sm_20`.

The central panel is titled "Run the process" and contains the following configuration options:

- Upload cards:  Nessun file selezionato
- Order:  Fixed Order:
- Shower:  Madspin:
- Reweight:  MadAnalysis:

A green "Submit run" button is located at the bottom of the configuration area.

# NLOAccess - run status

The screenshot shows a web browser window with the URL `nloaccess.in2p3.fr/tools/carlo.flore/account/run_status/`. The page header includes the NLOAccess logo and logos of partner institutions: Université Paris-Saclay, UCL, LPTHE, and INFN. The main heading is "NLOAccess - Carlo's runs".

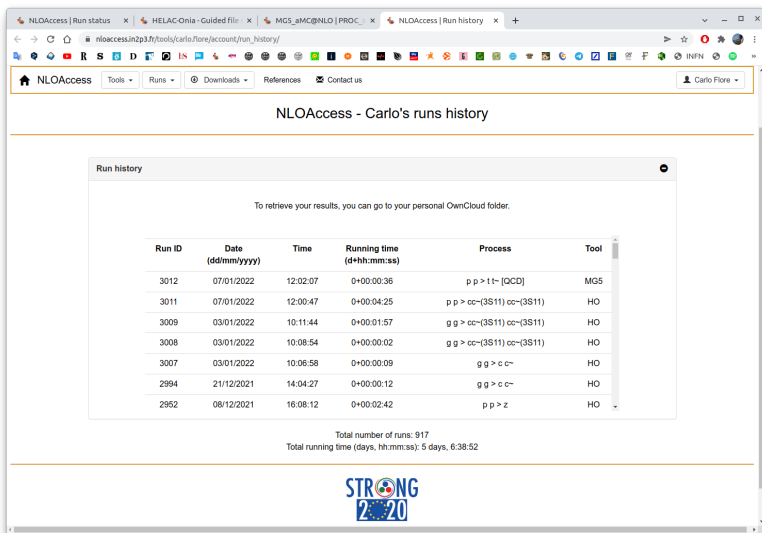
The "Run status" section contains a form with a text input for "Run id(s)" and a red "Remove run(s)" button. Below the form, a note states: "For removing multiple runs, separate the IDs with a comma or a semicolon."

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

At the bottom of the status section, there is a note: "This page will automatically refresh every 30 seconds. If you want to refresh now the page, click on the button below." with a blue "Refresh" button.




# 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 section titled "Run history" with a sub-header "To retrieve your results, you can go to your personal OwnCloud folder." Below this is a table with 6 columns: Run ID, Date (dd/mm/yyyy), Time, Running time (d+hh:mm:ss), Process, and Tool. The table contains 8 rows of data. At the bottom of the table, there is a summary: "Total number of runs: 917" and "Total running time (days, hh:mm:ss): 5 days, 6:38:52". At the very bottom of the page, there is a logo for "STRONG 2020" featuring the European Union flag.

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 > t t~ [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

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



# NLOAccess - what's next?

---

# NLOAccess - what's next?

---

- include **asymmetric collisions** in MG5 at NLO:

# NLOAccess - what's next?

- include **asymmetric collisions** in MG5 at NLO:  
extension to  $eh/eA$  collisions

[L. Manna, WUT Warsaw]

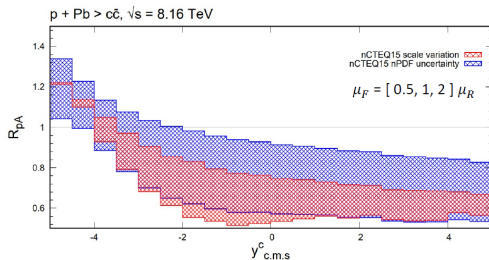
# NLOAccess - what's next?

- include **asymmetric collisions** in MG5 at NLO:  
extension to  $eh/eA$  collisions

[L. Manna, WUT Warsaw]

extension to  $pA/AB/\pi p$  collisions and automated computation of nuclear modification factors (e.g.  $R_{pA}$ )

[A. Safronov, WUT Warsaw]



from A. Safronov's talk at ICHEP 2022

# NLOAccess - what's next?

- inclusion of onium production at NLO in MG5

[A. Abdul-Hameed, LPTHE Paris]

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

[C. Flett, Jyvaskyla U. & IJCLab Orsay]

# NLOAccess - what's next?

- inclusion of onium production at NLO in MG5  
[A. Abdul-Hameed, LPTHE Paris]
- inclusion of spin and transverse momentum effects in  
HELAC-Onia  
[C. Flett, Jyvaskyla U. & IJCLab Orsay]
- inclusion of other codes  
[suggestions are welcome!]

# NLOAccess - what's next?

- inclusion of onium production at NLO in MG5  
[A. Abdul-Hameed, LPTHE Paris]
- inclusion of spin and transverse momentum effects in  
HELAC-Onia  
[C. Flett, Jyvaskyla U. & IJCLab Orsay]
- inclusion of other codes  
[suggestions are welcome!]

**Thank you**



**Backup**

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:

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

- $f_{i/p}(x_1), f_{j/p}(x_2)$  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)
- $\langle \mathcal{O}_n^{\mathcal{Q}} \rangle$  are the **LDMEs**

# NLOAccess - facts and figures

Some facts and figures about NLOAccess:

- general information at <https://nloaccess.in2p3.fr>
- HELAC-Onia Web: <https://nloaccess.in2p3.fr/H0/>
- MG5\_aMC@NLO: <https://nloaccess.in2p3.fr/MG5/>
- **345 users** from **+30 countries** all over the world; **~ 3800 runs**
- features:
  - **secure two-step registration** process
  - **protected OwnCloud storage** is given
  - **file input** as first way to submit a run
  - **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:

**STRONG 2020**

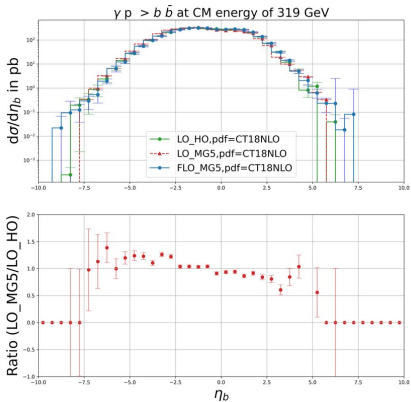
This e-infrastructure is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 624093.

SEARCH:

### RECENT POSTS

© Jean-Philippe Lansberg gives a talk at

# Result:



A comparison between pseudorapidity distribution of bottom quark production obtained from MG5 at LO (& FLO\*) and with another LO event generator called Helac-onia (HO).

Cross section (nb)	MG5	HO
LO	$3.34 \pm 4.4 \cdot 10^{-3}$	$3.34 \pm 10.08 \cdot 10^{-3}$
FLO	$3.34 \pm 19 \cdot 10^{-3}$	

\*FLO (It's a specialty in MG5 that NLO code could be used for LO calculation as well)

courtesy of L. Manna