



# **NLOAccess: a Virtual Access to automated perturbative QCD computations**

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# 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
- MadGraph and extension for nPDFs to be included
- ✓ HELAC-Onia is included

# HELAC-Onia

HELAC-Onia is an automatic matrix element and event generator for heavy quarkonium physics [H.-S. Shao, CPC 184 (2013) 2562-2570 & CPC 198 (2016) 238-259]

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

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- 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 & HELAC-Onia Web

Some facts about NLOAccess:

- general information at <https://nloaccess.in2p3.fr>
- HELAC-Onia Web: <https://nloaccess.in2p3.fr/HO/>
- note: **not definitive** working version
- 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
  - guided input file creation and submission for HO:  
[https://nloaccess.in2p3.fr/HO/downloads/HO\\_online\\_guide\\_v01.pdf](https://nloaccess.in2p3.fr/HO/downloads/HO_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

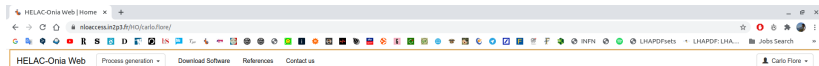
© Jean-Philippe Lansberg gives a talk at

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

$d\sigma/dP_T$  (nb/GeV) vs  $P_T$  (GeV) plot showing curves for  $J/\psi$ ,  $\psi(2S)$ ,  $\chi_{c0}$ ,  $\chi_{c1}$ ,  $\chi_{c2}$ ,  $\psi(3S)$ ,  $\chi_{c3}$ ,  $\psi(4S)$ ,  $\chi_{c4}$ ,  $\psi(5S)$ ,  $\chi_{c5}$ ,  $\psi(6S)$ ,  $\chi_{c6}$ ,  $\psi(7S)$ ,  $\chi_{c7}$ ,  $\psi(8S)$ ,  $\chi_{c8}$ ,  $\psi(9S)$ ,  $\chi_{c9}$ ,  $\psi(10S)$ ,  $\chi_{c10}$ ,  $\psi(11S)$ ,  $\chi_{c11}$ ,  $\psi(12S)$ ,  $\chi_{c12}$ ,  $\psi(13S)$ ,  $\chi_{c13}$ ,  $\psi(14S)$ ,  $\chi_{c14}$ ,  $\psi(15S)$ ,  $\chi_{c15}$ ,  $\psi(16S)$ ,  $\chi_{c16}$ ,  $\psi(17S)$ ,  $\chi_{c17}$ ,  $\psi(18S)$ ,  $\chi_{c18}$ ,  $\psi(19S)$ ,  $\chi_{c19}$ ,  $\psi(20S)$ ,  $\chi_{c20}$ ,  $\psi(21S)$ ,  $\chi_{c21}$ ,  $\psi(22S)$ ,  $\chi_{c22}$ ,  $\psi(23S)$ ,  $\chi_{c23}$ ,  $\psi(24S)$ ,  $\chi_{c24}$ ,  $\psi(25S)$ ,  $\chi_{c25}$ ,  $\psi(26S)$ ,  $\chi_{c26}$ ,  $\psi(27S)$ ,  $\chi_{c27}$ ,  $\psi(28S)$ ,  $\chi_{c28}$ ,  $\psi(29S)$ ,  $\chi_{c29}$ ,  $\psi(30S)$ ,  $\chi_{c30}$ ,  $\psi(31S)$ ,  $\chi_{c31}$ ,  $\psi(32S)$ ,  $\chi_{c32}$ ,  $\psi(33S)$ ,  $\chi_{c33}$ ,  $\psi(34S)$ ,  $\chi_{c34}$ ,  $\psi(35S)$ ,  $\chi_{c35}$ ,  $\psi(36S)$ ,  $\chi_{c36}$ ,  $\psi(37S)$ ,  $\chi_{c37}$ ,  $\psi(38S)$ ,  $\chi_{c38}$ ,  $\psi(39S)$ ,  $\chi_{c39}$ ,  $\psi(40S)$ ,  $\chi_{c40}$ ,  $\psi(41S)$ ,  $\chi_{c41}$ ,  $\psi(42S)$ ,  $\chi_{c42}$ ,  $\psi(43S)$ ,  $\chi_{c43}$ ,  $\psi(44S)$ ,  $\chi_{c44}$ ,  $\psi(45S)$ ,  $\chi_{c45}$ ,  $\psi(46S)$ ,  $\chi_{c46}$ ,  $\psi(47S)$ ,  $\chi_{c47}$ ,  $\psi(48S)$ ,  $\chi_{c48}$ ,  $\psi(49S)$ ,  $\chi_{c49}$ ,  $\psi(50S)$ ,  $\chi_{c50}$ ,  $\psi(51S)$ ,  $\chi_{c51}$ ,  $\psi(52S)$ ,  $\chi_{c52}$ ,  $\psi(53S)$ ,  $\chi_{c53}$ ,  $\psi(54S)$ ,  $\chi_{c54}$ ,  $\psi(55S)$ ,  $\chi_{c55}$ ,  $\psi(56S)$ ,  $\chi_{c56}$ ,  $\psi(57S)$ ,  $\chi_{c57}$ ,  $\psi(58S)$ ,  $\chi_{c58}$ ,  $\psi(59S)$ ,  $\chi_{c59}$ ,  $\psi(60S)$ ,  $\chi_{c60}$ ,  $\psi(61S)$ ,  $\chi_{c61}$ ,  $\psi(62S)$ ,  $\chi_{c62}$ ,  $\psi(63S)$ ,  $\chi_{c63}$ ,  $\psi(64S)$ ,  $\chi_{c64}$ ,  $\psi(65S)$ ,  $\chi_{c65}$ ,  $\psi(66S)$ ,  $\chi_{c66}$ ,  $\psi(67S)$ ,  $\chi_{c67}$ ,  $\psi(68S)$ ,  $\chi_{c68}$ ,  $\psi(69S)$ ,  $\chi_{c69}$ ,  $\psi(70S)$ ,  $\chi_{c70}$ ,  $\psi(71S)$ ,  $\chi_{c71}$ ,  $\psi(72S)$ ,  $\chi_{c72}$ ,  $\psi(73S)$ ,  $\chi_{c73}$ ,  $\psi(74S)$ ,  $\chi_{c74}$ ,  $\psi(75S)$ ,  $\chi_{c75}$ ,  $\psi(76S)$ ,  $\chi_{c76}$ ,  $\psi(77S)$ ,  $\chi_{c77}$ ,  $\psi(78S)$ ,  $\chi_{c78}$ ,  $\psi(79S)$ ,  $\chi_{c79}$ ,  $\psi(80S)$ ,  $\chi_{c80}$ ,  $\psi(81S)$ ,  $\chi_{c81}$ ,  $\psi(82S)$ ,  $\chi_{c82}$ ,  $\psi(83S)$ ,  $\chi_{c83}$ ,  $\psi(84S)$ ,  $\chi_{c84}$ ,  $\psi(85S)$ ,  $\chi_{c85}$ ,  $\psi(86S)$ ,  $\chi_{c86}$ ,  $\psi(87S)$ ,  $\chi_{c87}$ ,  $\psi(88S)$ ,  $\chi_{c88}$ ,  $\psi(89S)$ ,  $\chi_{c89}$ ,  $\psi(90S)$ ,  $\chi_{c90}$ ,  $\psi(91S)$ ,  $\chi_{c91}$ ,  $\psi(92S)$ ,  $\chi_{c92}$ ,  $\psi(93S)$ ,  $\chi_{c93}$ ,  $\psi(94S)$ ,  $\chi_{c94}$ ,  $\psi(95S)$ ,  $\chi_{c95}$ ,  $\psi(96S)$ ,  $\chi_{c96}$ ,  $\psi(97S)$ ,  $\chi_{c97}$ ,  $\psi(98S)$ ,  $\chi_{c98}$ ,  $\psi(99S)$ ,  $\chi_{c99}$ ,  $\psi(100S)$ ,  $\chi_{c100}$

# HELAC-Onia Web - Homepage

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



## Automated perturbative calculation with HELAC-Onia Web

### Welcome to HELAC-Onia Web!

HELAC-Onia is an automatic matrix element generator for the calculation of the heavy quarkonium helicity amplitudes in the framework of NRQCD 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.

Generate a process or submit your input file, or logout.



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.

# HELAC-Onia Web - Run submission

The screenshot shows a web browser window with the URL `niaaccess.in2p3.fr/110/carlo/fone/file_sub_guided/`. The page title is "HELAC-Onia Web" and the navigation menu includes "Process generation", "Download Software", "References", and "Contact us". The user is logged in as "Carlo Flore".

### HELAC-Onia - Guided file submission

**Create an input file**

**Input next command(s):**

[Add command\(s\)](#)

**Remove line(s) containing:**

[Remove line\(s\)](#) [Clear file](#)

[Submit job](#)

**Your input file:**

```
generate p p > cc-(3S11) cc-(3S11) g
set energy_beam1 = 3500.0
set energy_beam2 = 3500.0
set qod = 2
set Scale = 1
set ScaleFactor = 1.0
set minpionia = 5.0
set nms = 1000000
set nopt = 100000
set nopt_stop = 100000
set nopt_lim = 1000000
launch
```

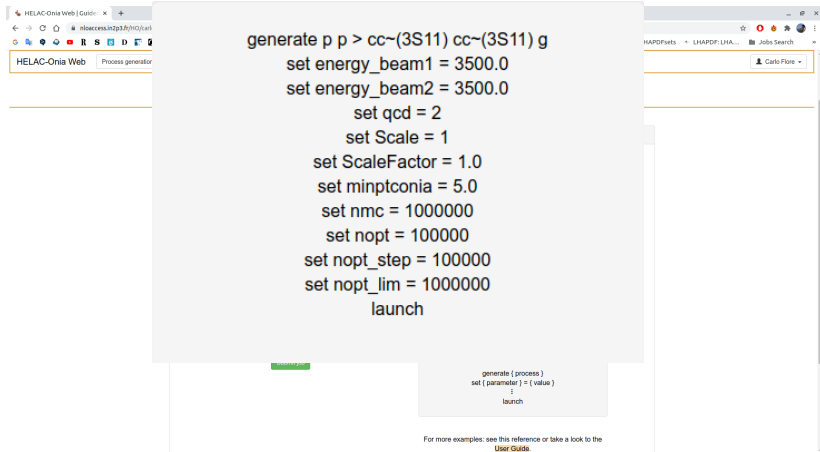
Please, remember to follow this structure for your input file:

```
generate [ process ]
set ( parameter ) = ( value )
:
:
launch
```

For more examples: see [this reference](#) or take a look to the [User Guide](#).



# HELAC-Onia Web - Run submission



The image shows a screenshot of the HELAC-Onia Web interface. On the left, a browser window displays the URL `nloaccess.in2p3.fr/h10/carlo` and the page title "HELAC-Onia Web". The main content area contains a "Process generator" form. A large grey box is overlaid on the form, containing the following submission parameters:

```
generate p p > cc~(3S11) cc~(3S11) g
set energy_beam1 = 3500.0
set energy_beam2 = 3500.0
set qcd = 2
set Scale = 1
set ScaleFactor = 1.0
set minptconia = 5.0
set nmc = 1000000
set nopt = 100000
set nopt_step = 100000
set nopt_lim = 1000000
launch
```

Below the code block, a smaller grey box shows the syntax for the `generate` command:

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

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

# HELAC-Onia Web - Run status

HELAC-Onia Web | Run status

HELAC-Onia Web Process generation Download Software References Contact us Carlo Flore

NLOAccess Université Paris-Saclay UCL LPTHE PPIO INFN

### HELAC-Onia Web - Carlo's runs

Run status

Run id(s)  [Remove \(x/0\)](#)

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

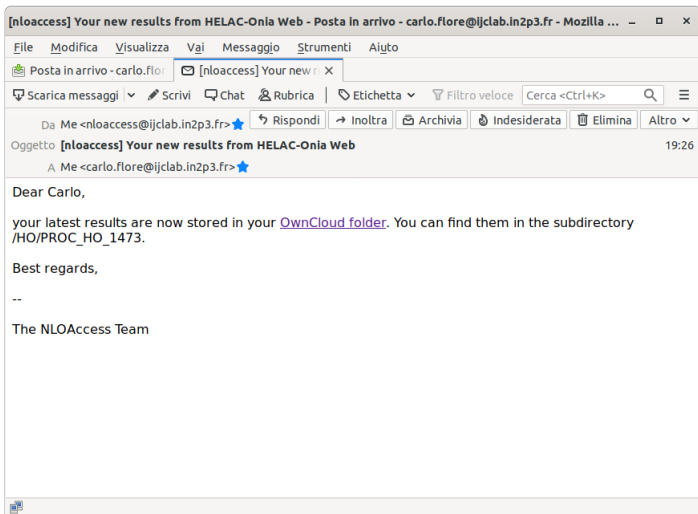
Run ID	Date (dd/mm/yyyy)	Time (d+hh:mm:ss)	Idle	Running	Completed	Process
1473	06/03/2021	17:29:37	0	7	0	p p > cc-(3511) cc-(3511) g

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

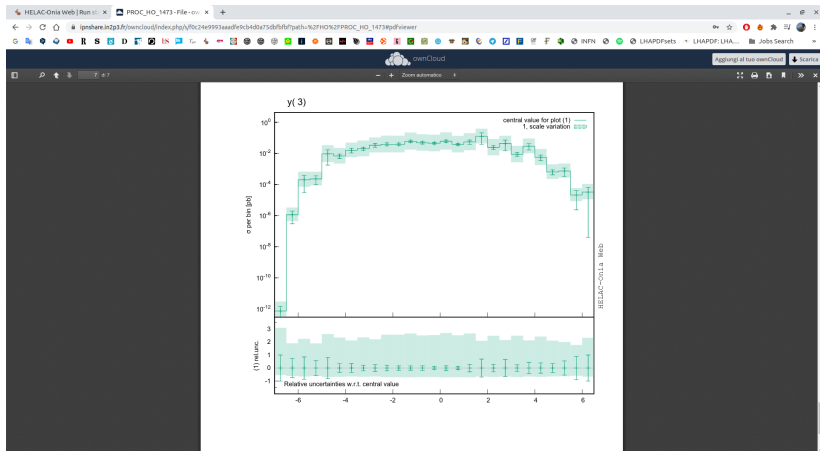
[Refresh](#)

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# HELAC-Onia Web - Results (I)



# HELAC-Onia Web - Results (II)



# HELAC-Onia Web - Run history

HELAC-Onia Web | Run history

Process generation | Download Software | References | Contact us

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## HELAC-Onia Web - Carlo's runs history

### Run history

To retrieve your results, you can go to your personal OwnCloud folder.

Run ID	Date (dd/mm/yyyy)	Time	Running time (d+hh:mm:ss)	Process
1470	05/03/2021	11:07:59	0+04:23:34	p p > cc-(3S11) cc-(3S11) g
1469	04/03/2021	16:03:52	0+00:00:16	g g > c c-
1468	04/03/2021	15:41:24	Removed	p p > cc-(3S11) cc-(3S11) g
1467	04/03/2021	15:38:32	Removed	p p > cc-(3S11) cc-(3S11) g
1466	04/03/2021	15:29:06	Removed	p p > cc-(3S11) cc-(3S11) g
1465	04/03/2021	15:29:00	Removed	p p > cc-(3S11) cc-(3S11) g
1464	04/03/2021	15:28:03	Removed	p p > cc-(3S11) cc-(3S11) g

Total number of runs: 375  
Total running time (days, hh:mm:ss): 1 day, 19:28:35

# NLOAccess - What's next?

## MadGraph:

- MadGraph online version is only limited to LO calculation
- NLO preliminary version has already been tested (not public)
- extension to nPDFs  $\Rightarrow$  extend calculation to other observables (e.g.  $R_{pA}$  or  $R_{AA}$ )

## HELAC-Onia developments:

- NLO calculations
- inclusion of TMD effects
- helpful for future fixed-target programs at the LHC

**Thank you**