The NLOAccess project

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Progress in algorithms and numerical tools for QCD
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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

✓ 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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NRQCD factorisation:

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

- $f_{i/p}(x_1), f_{j/p}(x_2)$ are the PDFs
- $\hat{\sigma}(ij \to Q\bar{Q}[n] + X)$ 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

HELAC-Onia (II)

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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

http://amcatnlo.web.cern.ch/amcatnlo/list_refs.htm

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

What is the main difference between HELAC-Onia and MG5_aMC@NLO?

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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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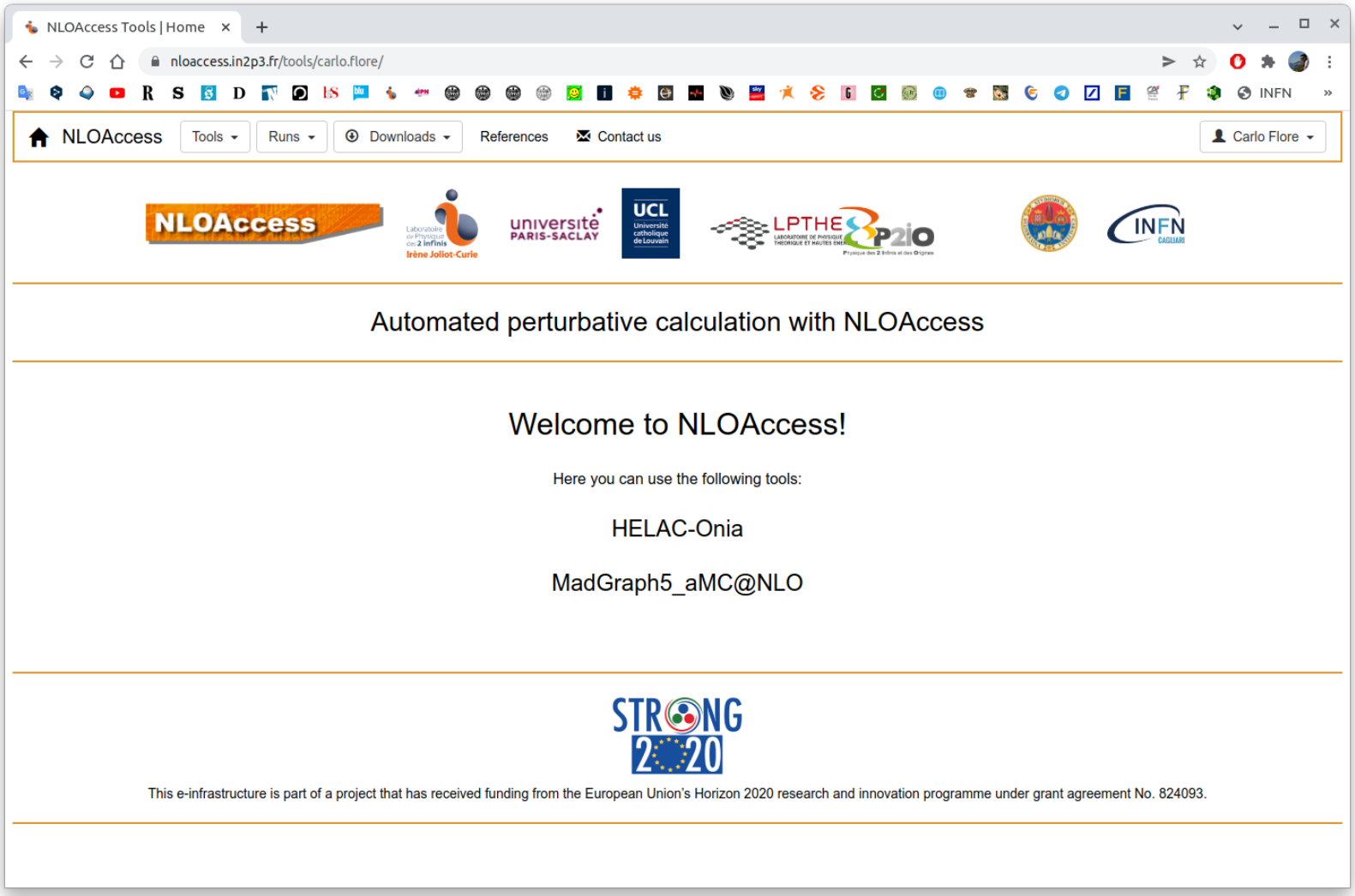
  - guided input file creation and submission for HO: https://nloaccess.in2p3.fr/HO/downloads/HO_online_guide_v01.pdf

NLOAccess - Homepage

(https://nloaccess.in2p3.fr)

NLOAccess Tools - Homepage

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



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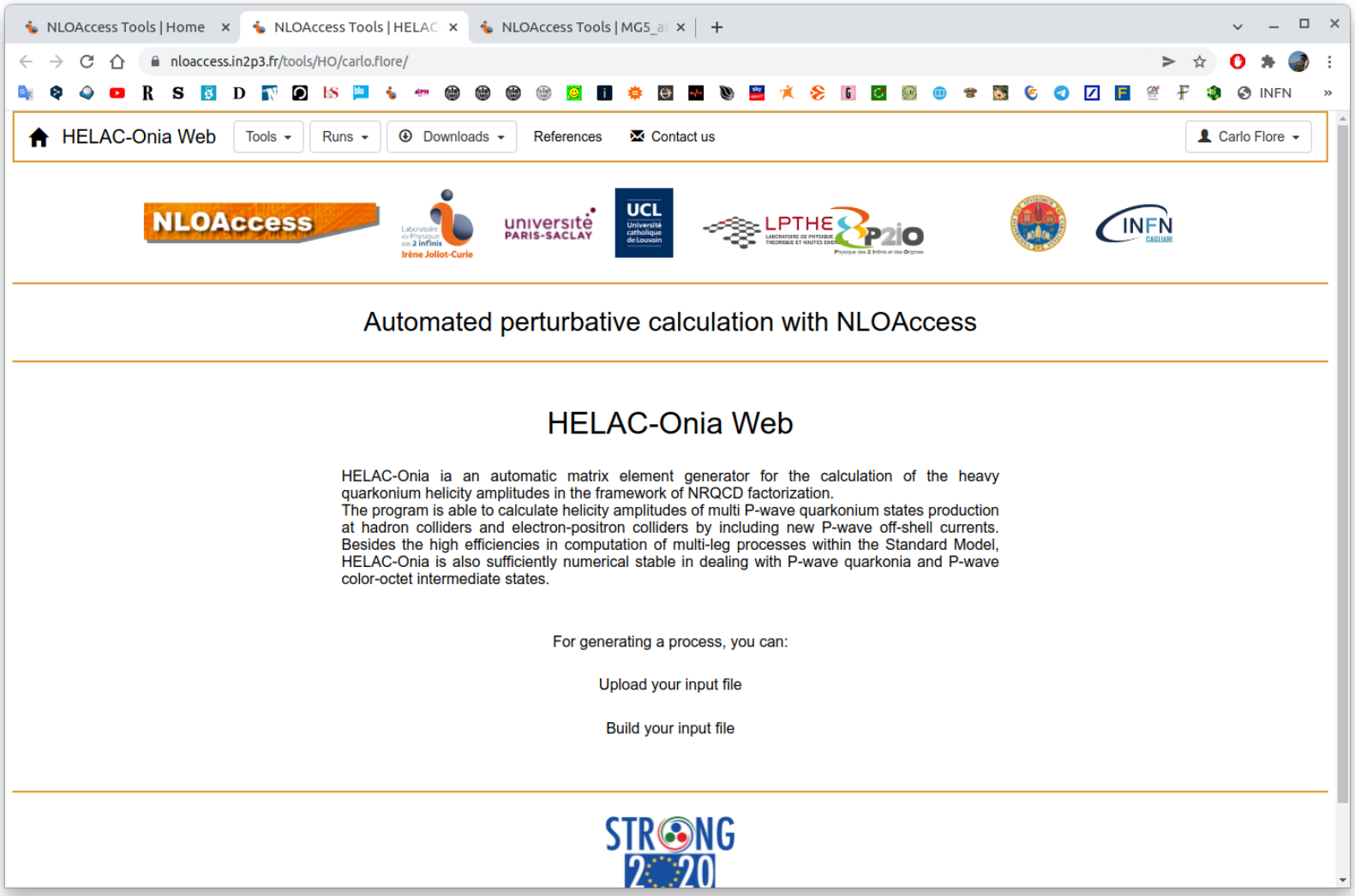
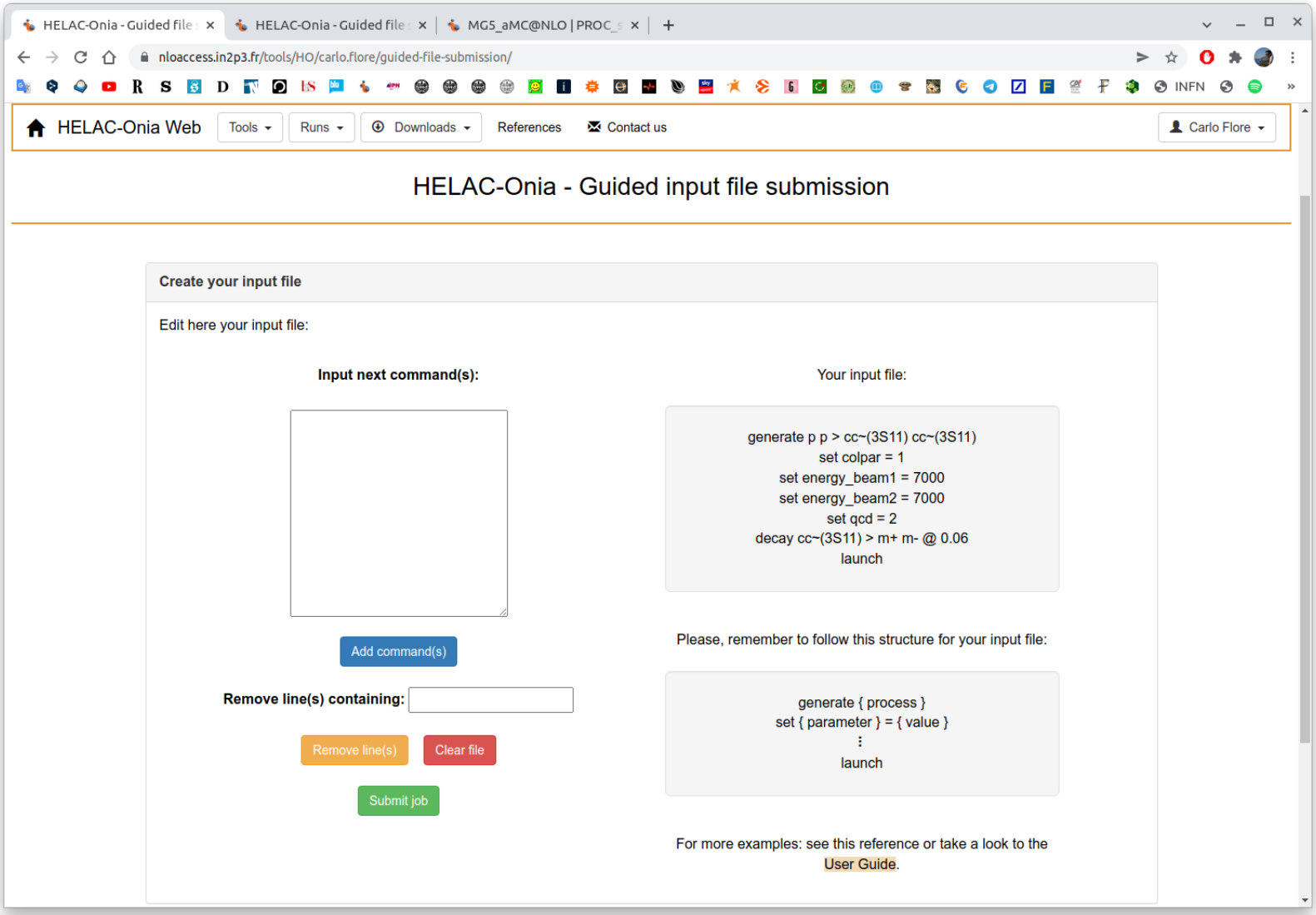


HELAC-Onia Web - Run submission



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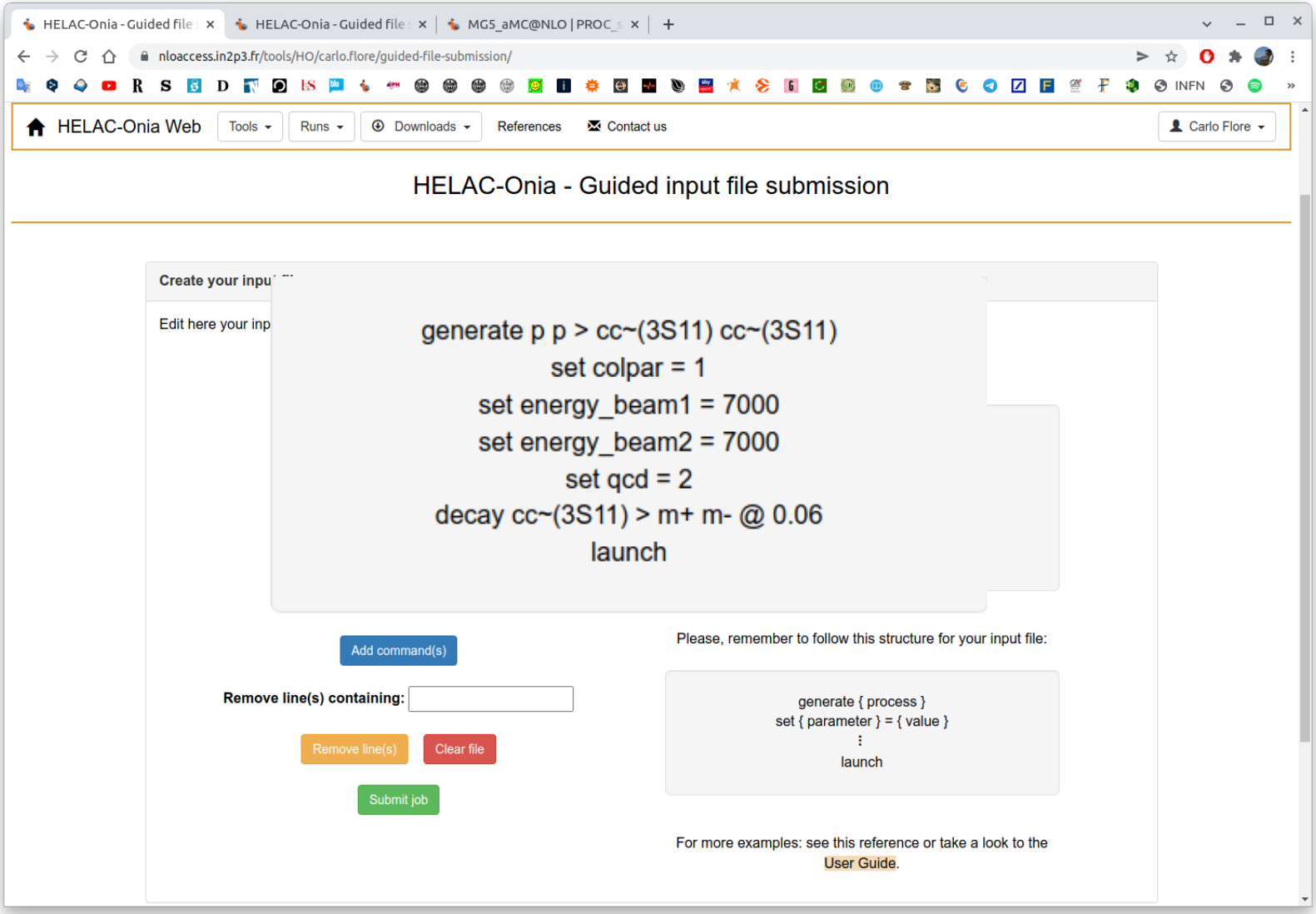


HELAC-Onia Web - Input file

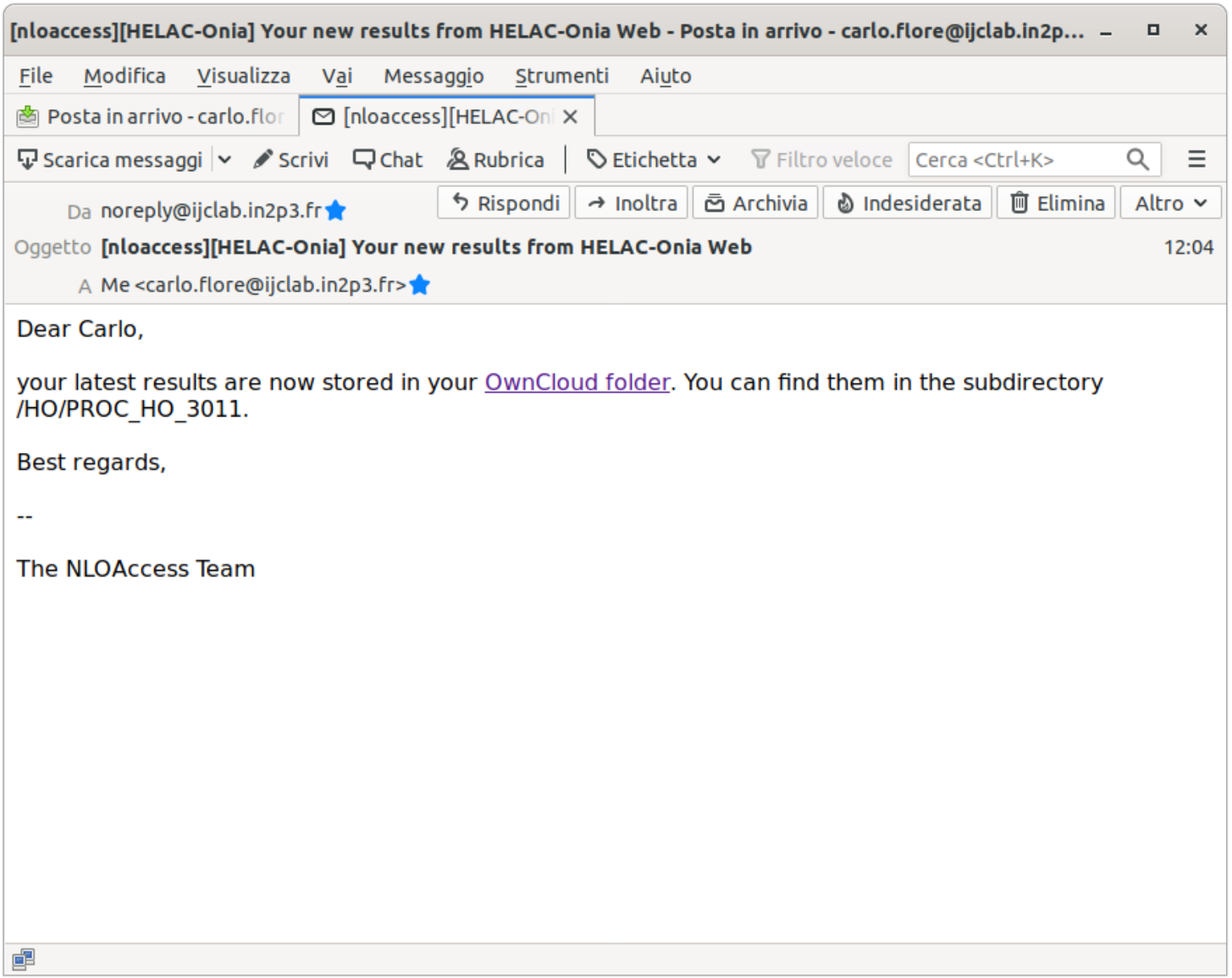
The input file should be in the following form:

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

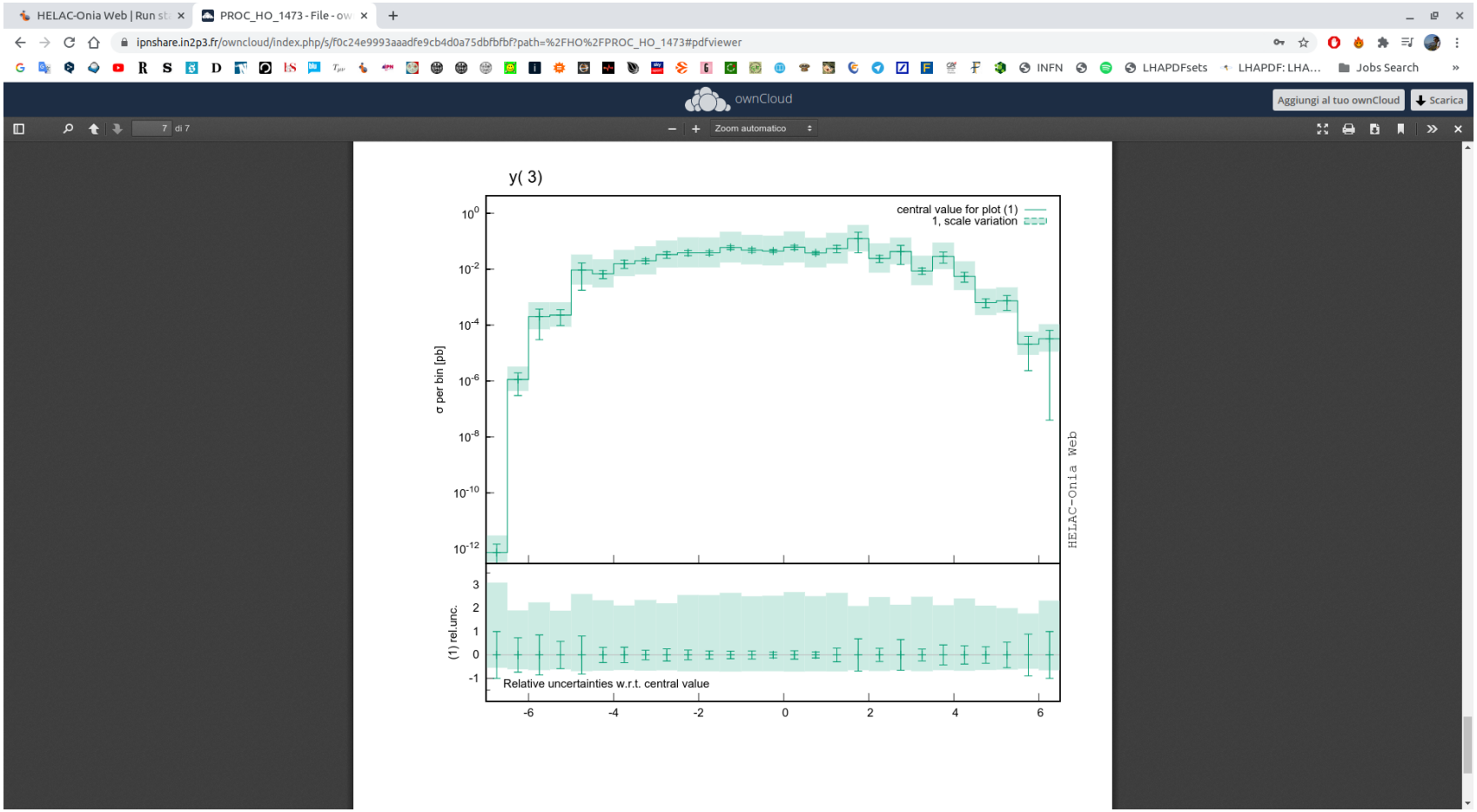
Users can have control on several kind of parameters via the `set` command:

- 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)



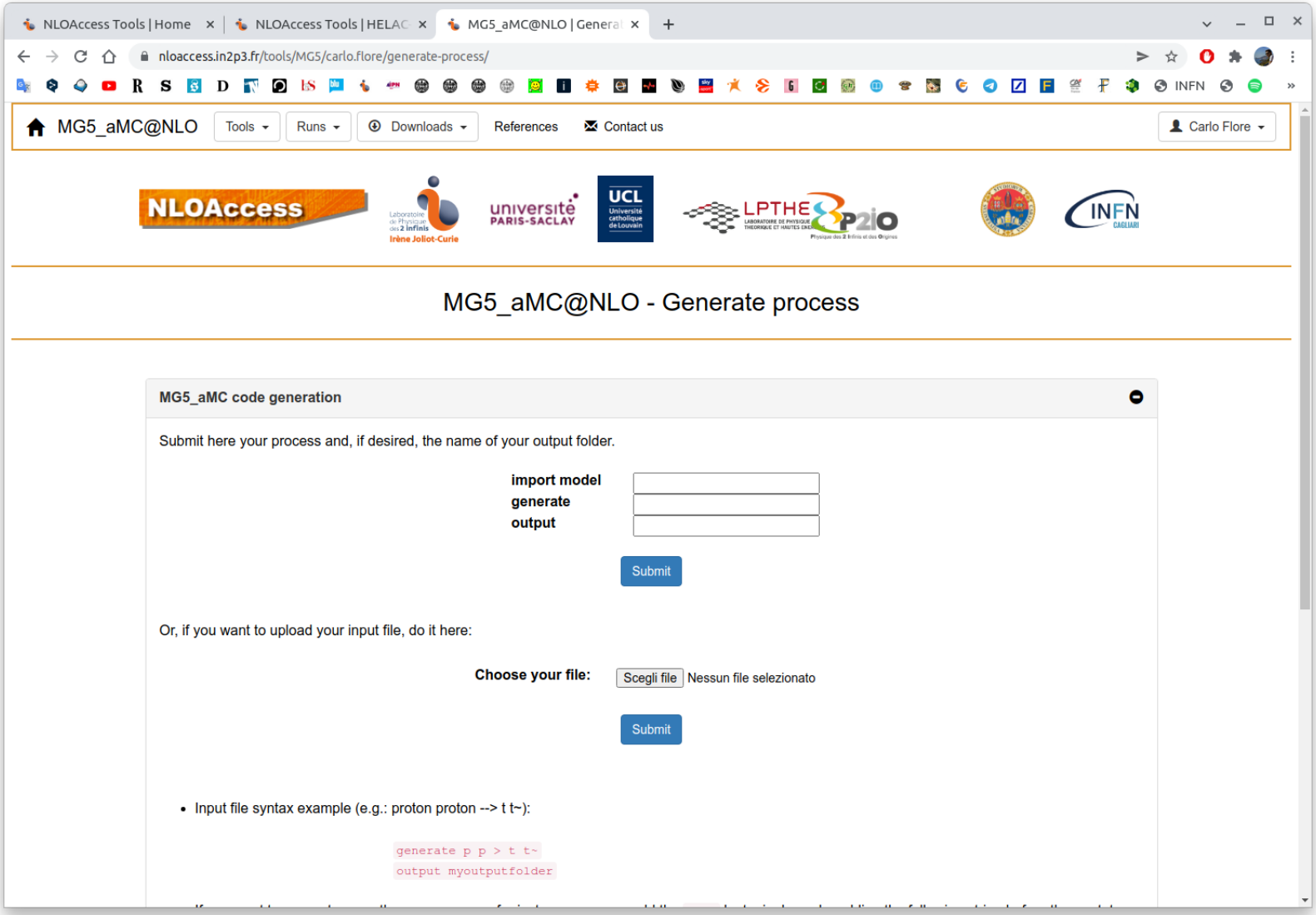
HELAC-Onia Web - Results (II)



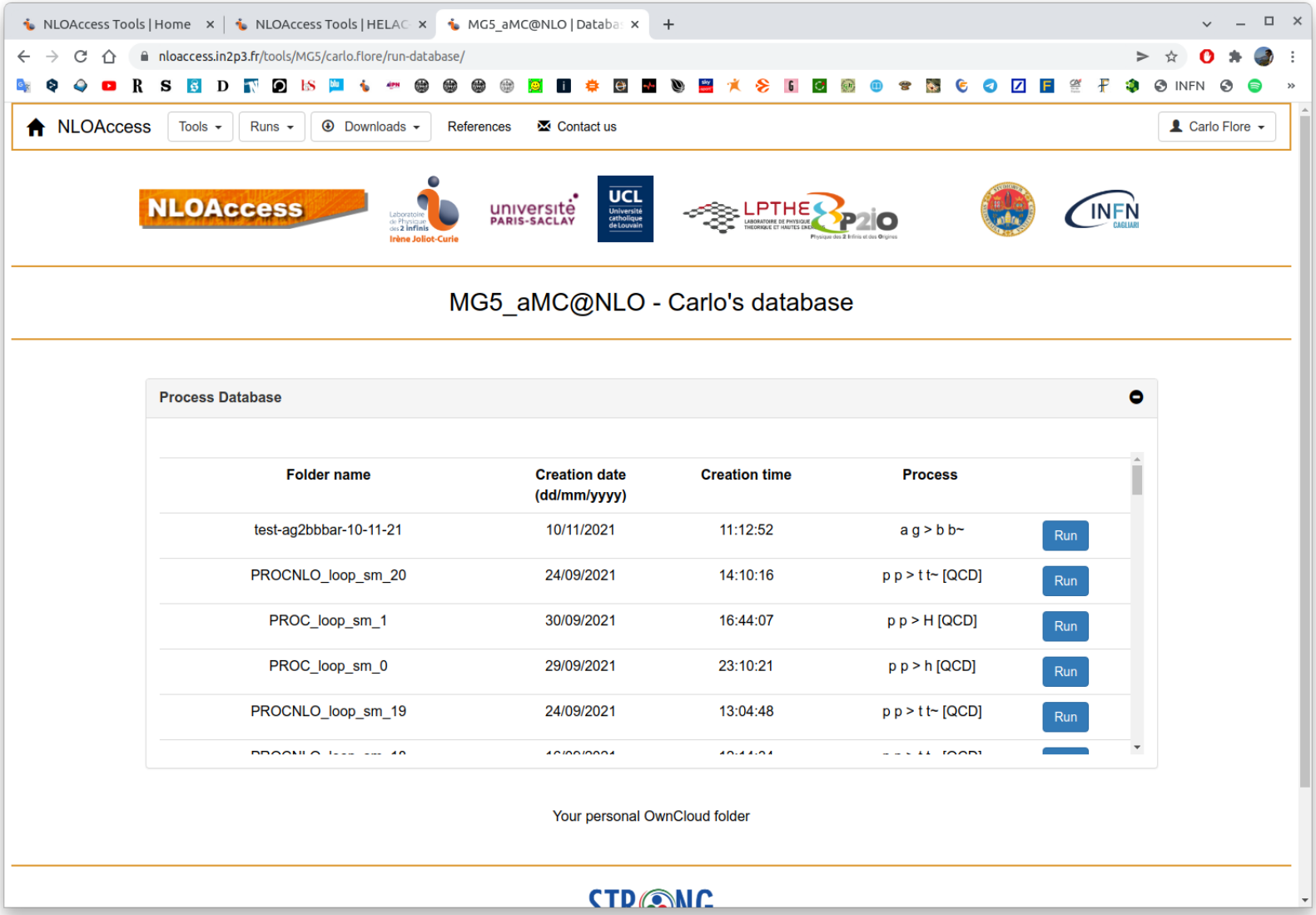
MG5_aMC@NLO (https://nloaccess.in2p3.fr/MG5/)

- 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!

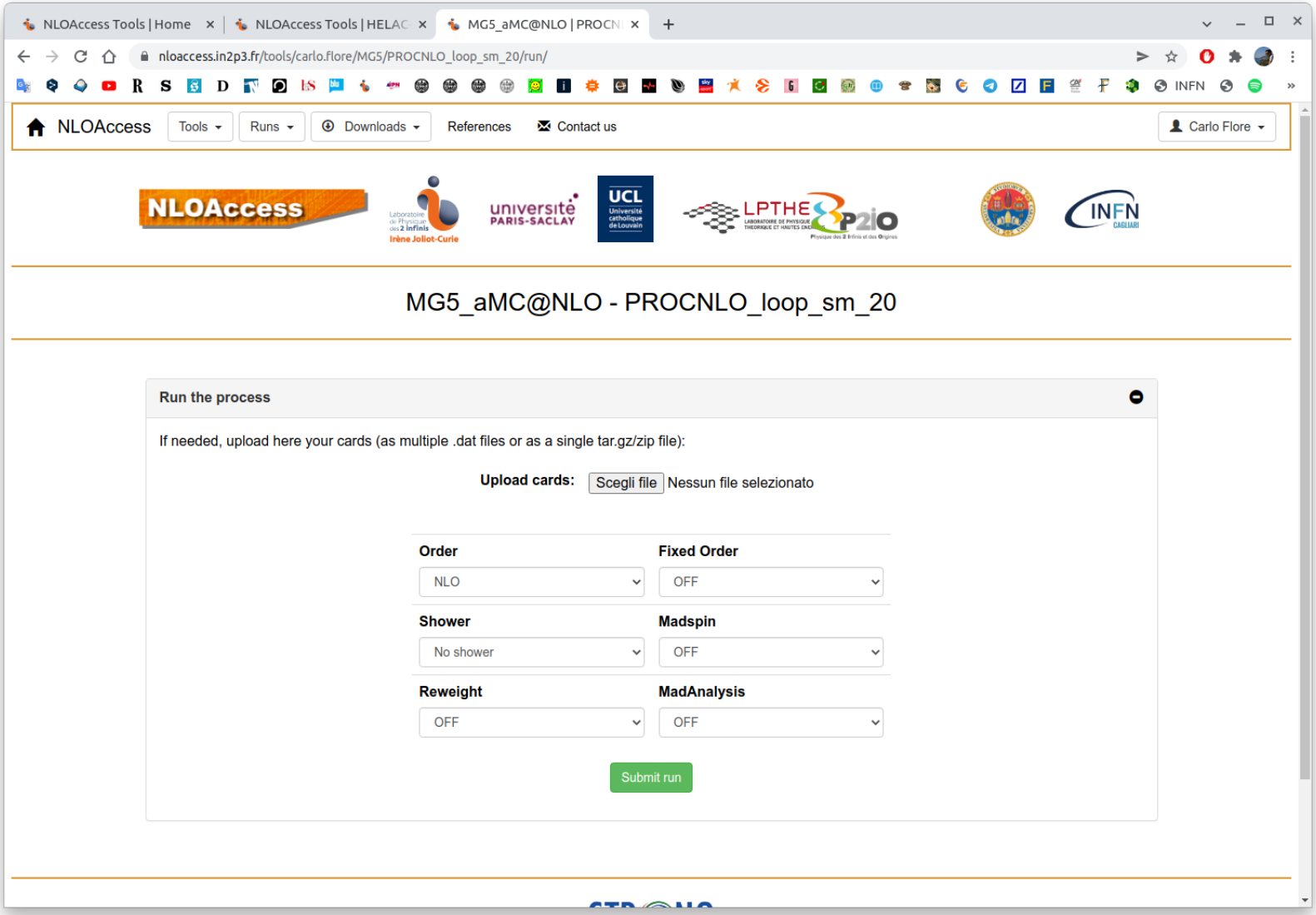
MG5_aMC@NLO - code generation



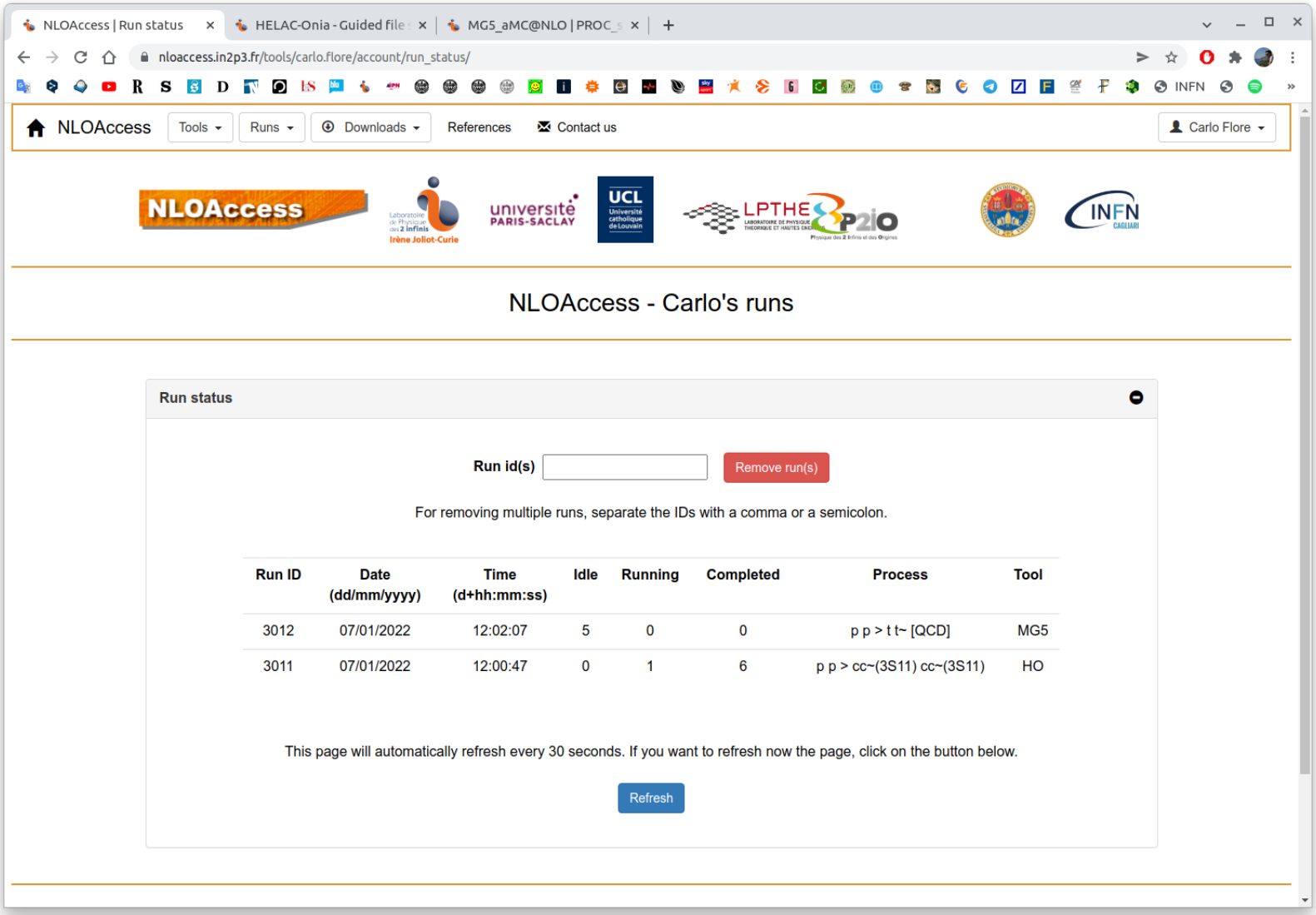
MG5_aMC@NLO - code database



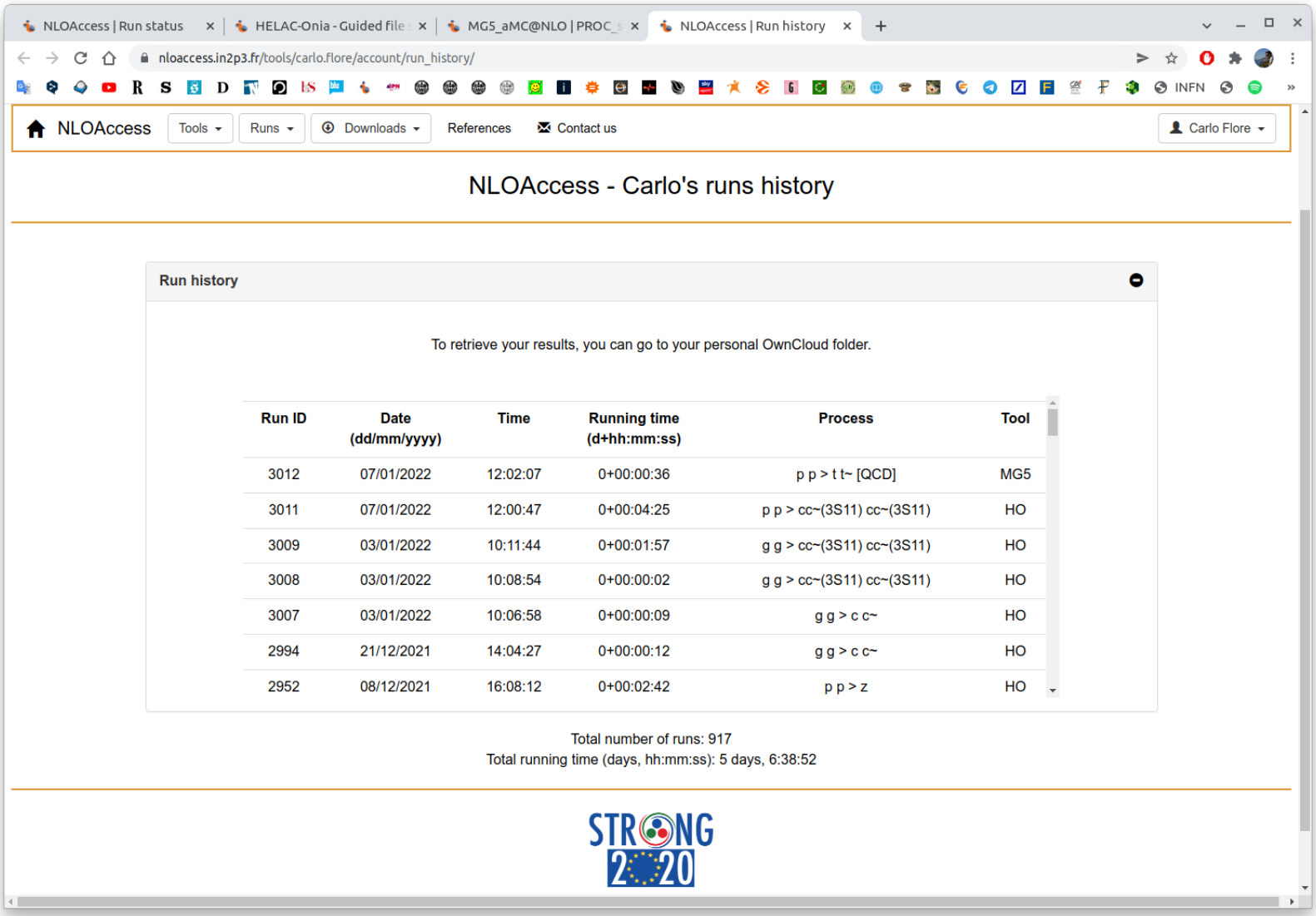
MG5_aMC@NLO - code running



NLOAccess - Run status



NLOAccess - Run history



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

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  [suggestions are welcome!]

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