NLOAccess for Horizon Europe

A Virtual Access to automated computations of hard-scattering observables in hadronic, particle and nuclear physics

D. Kikola (WUT, Warsaw), J.P. Lansberg (CNRS, IJCLab), O. Mattelaer (UCLouvain), C. Pisano (INFN, Cagliari U.)

01/07/2025

The NLOAccess VA [https://nloaccess.in2p3.fr]

NLOAccess is one of the two existing Virtual Access funded by the EU Horizon 2020 project STRONG-2020.

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- Free access provision to automated perturbative QCD calculations for (initially) heavy ions and quarkonia
- Automated and versatile: everyone would be able to evaluate physical observables related to hadron scatterings without need to install or pre-code anything
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Facts & figures:

- secure two-step registration process with personal protected OwnCloud storage
- file/cards input to submit a run + graphical user interface
- to date, 790 users from all over the world
- 60 tutorials, hands-on session and talks; 17 published papers and 5 proceedings. Many master thesis.
- EU funding : 48 + 12 h.m. (CNRS + UCL) for research engineers + funding from WUT for 112 h.m of PhD students (A. Safronov, L. Manna, A. Colpani Serri)

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State-of-the-art services and improvements:

- full NLO online automated computations with MG5 incl. BSM [extends to the entire HEP community]
- Inclusion of asymmetric hadron-nucleus collisions (πp, pA, AB) in MG5
- Inclusion of LO automated quarkonium production in MG5 [soon online, talk @HEP-EPS]

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Links:

- HELAC-Onia: https://nloaccess.in2p3.fr/HO/
- MadGraph5 (MG5): https://nloaccess.in2p3.fr/MG5/

NLOAccess - International Assessment Board

NLOAccess was followed by an International Assessment Board (IAB) of eight researchers:
4 experimentalists+4 theorists; 5 from EU + 3 from non-EU institution; gender balanced

IAB Members:

1. Prof. Asmita Mukherjee, IIT Mumbai, India (Theory, Spin physics)
2. Dr. Barbara Trzeciak, CTU Prague, Czech Republic (Experiment, STAR - EIC)
3. Dr. Cynthia Hadjidakis, IJCLab Orsay, France (Experiment, ALICE)
4. Prof. Elena Ferreiro, USC, Spain (Theory, Heavy-Ion Physics)
5. Dr. Emilien Chapon, CEA, DPhP (Experiment, ATLAS)
6. Dr. Nodoka Yamanaka, RIKEN, Japan (Theory, Nuclear and Hadronic Physics)
7. Dr. Marc Schlegel, Tübingen U., Germany (Theory, Spin physics)
8. Prof. Zhenwei Yang, Peking U., China (Experiment, LHCb)

The present call: HORIZON_HORIZON-INFRA-2025-01-SERV-03

Research infrastructure services advancing frontier knowledge

    https://cordis.europa.eu/programme/id/HORIZON_HORIZON-INFRA-2025-01-SERV-03

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*The **main goal** of this topic is **access provision to existing services**: this should be clearly reflected by the proposed activities and the allocated resources. The **improvement and optimisation** of the offered services and the development of **new services**, relevant to specific scientific challenges in the identified domains, can also be supported, including joint/cross-research infrastructure services, provided that the resulting services are **opened and offered already under the actions** (short-term R&D) and that the **long-term sustainability** of such services is ensured by the participant research infrastructures. This topic will not support longer-term R&D for new instrumentation, tools, methods and advanced digital solutions*

WP1: maintenance of the e-infrastructure [requested support: 58 h.m.]

Given the large size of the user community (800), a specific maintenance effort is needed for a reliable service at any time !

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2 activities :

1. NLOAccess maintenance and consolidation (46 h.m. of research engineer)

   - Hardware (300 cores @ VirtualData; 20 k€ for upgrade)
   - Cloud (result storage: 8 Tb)
   - Database (EGDPR, security, interaction with the community)

2. Training, dissemination, communication and helpdesk activities (12 h.m.)

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   - Reliable service
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   - Improved interactions with users: creation of an helpdesk for interactive exchanges via tickets + monthly live tutorial sessions
   - Master classes during Schools
   - Support for interactive lectures

WP2: optimisation of the e-infrastructure [requested support: 48 h.m.]

5 activities :

1. Upgrade to MG7 + MG7NLO and improved GUI for plotting (12 h.m.)
2. Credential transfer (6 h.m.)
3. Software adaptation if credential transfer (3 h.m.)
4. Neural network integrator – MadNIS (https://madnis.ai/) (9 h.m.)
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- Optimisation of resources with upgrade of MG to v7 (more efficient ME generation and event integration)
- Online access to remote HPC resources (IN2P3, INFN, CERN GRID, …) for intensive computations for e.g. NNLO codes: exploration of credential transfer of the NLOAccess users

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- More flexible plotting capabilities for the users
- Access to new technologies (GPUs) ($\times$5 faster just for MG)
- Inclusion of AI-based phase-space integrators (MadNIS, https://madnis.ai/) ($\times$10 faster just for MG)
- Better handling of high-multiplicity events (multi jets) and specific integration (quarkonia)

WP3: new services – new access to codes [requested support: 36 h.m.]

New access to 5 codes complementary to the existing ones

5 activities :

1. STARlight (9 h.m.)
2-3. Exclusive lepto- and photo- production codes of quarkonia at NLO (9 h.m.)
4. SuperCHIC (9 h.m.)
5. INCNLO for (very) high-P_T hadrons & quarkonium production with collinear fragmentation functions (FFs) (9 h.m.)

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Objectives: reach new regimes and new communities

- Photon-induced relativistic-ion collisions with a online access to STARlight and SuperCHIC
- Exclusive production of quarkonia with online access to 2 NLO codes (for JLab, EIC, LHeC, UPC@LHC) + test a possible interface to the VA GPD-Portal
- High-p_T hadrons in *pp* collisions using collinear FFs at NLL via online access to INCNLO with possible interface to the VA TMD-Portal and generation of a quarkonium-FF library (LHC & FCC)

WP4: Extension of MG [requested support: 39 h.m.]

Extension of MG to new hadronic reactions at NLO for online usage

3 activities:
- Deep-Inelastic Scattering in MG7 at NLO (12 h.m.)
- Quarkonium production in MG7 at NLO (15 h.m.)
- TMD hard scatterings using helicity-dependent amplitudes in MG7 up to NLO (12 h.m.)

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- Objective: Enlarge the existing community and reach neighboring communities:
  - EIC, LHeC, JLab, and FCC-eh via DIS
  - LHC, RHIC, EIC, FCC and fixed-target experiments via quarkonium production in all the production modes
  - LHC, RHIC, EIC, JLab, FCC and fixed-target experiments via processes involving TMD distributions (possible interface with VA TMD-Portal + coupling with GPU computations for TMD evolution)

WP5: new online tools [requested support: 47 h.m.]

Creation & access to 5 novel tools for the hadronic and nuclear physics communities

5 activities:

1. Tool and online interface for nuclear PDFs in a Glauber MC for *pA*, *AA* and *eA* collisions using the experimental centrality (18 h.m.)

2. Tools for automated online usage of diffractive PDFs via LHAPDF for the LHC and EIC (4 h.m.)

3. Tool for automated online usage of resolved photon PDFs for inclusive UPCs at LHC and *ep* collisions at LHeC & FCC-eh via LHAPDF (4 h.m.)

4. Online tool for Pythia, Double Parton Scattering and quarkonium production at LHC, RHIC & EIC: tunes and colour reconnection effects (18 h.m.)

5. Online interface to gamma-UPC (See H.S. Shao's presentation) (3 h.m.)

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Objectives

- New standalone tools interfacing HEP, hadronic and nuclear physics
- New online services
- Wider community

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- CERN TNA: several collaboration meetings held there during STRONG-2020; GPU-related task with a CERN team
- BNL TNA: Simulation tool for the EIC (DIS, photoproduction, data-driven quarkonium MC samples, ...)
- ECT* TNA : one workshop organised there during STRONG-2020; plan to contribute to one of the yearly doctoral programs towards reliable MC simulation for experimental programs and new theory developments on MC;
- VA GPD Portal & TMD Portal: non-perturbative inputs needed to compute observables on NLOAccess: 3 specific activities with interface with both VAs; on-going projects on quarkonium photoproduction and FFs with PARTONS people

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- Contact persons to experimental collaboration:
  ALICE: S. Porteboeuf (LPCA); ATLAS: V. Kartvelishishvili (Lancaster); CMS: C. Van Hulse (IIHE); LHCb: R. McNulty (UCD); FT@LHC: C. Hadjidakis (IJCLab); EIC: D. Kikola (WUT); STAR: B. Trzeciak (CTU); PHENIX: C. Da Silva (LANL); LHeC and FCC-eh: J.P. Lansberg (IJCLab); FCC-ee and FCC-hh: D. d'Enterria (CERN)

Budget request
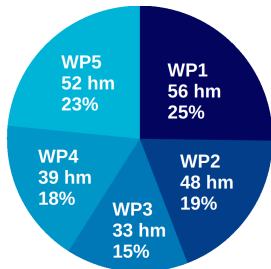
- 192 h.m. would be : 2/3 y research engineer contracts (50k€/year) for the 4 labs following the profiles hired during STRONG2020;

- 36 h.m. for one postdoctoral researcher (60k€/year) needed for coordination of the scientific objectives for the developments of new codes or tools

- All hired personnel will work in close collaboration with the 20+ participating laboratories and will welcome inputs from the entire consortium

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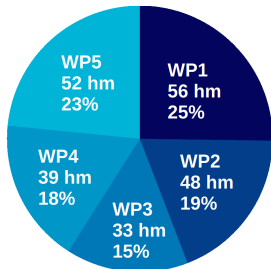
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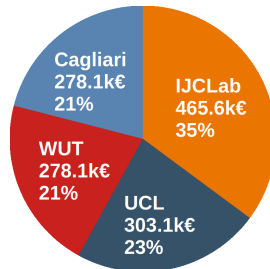
- replacement of the oldest part of the NLOAccess computational cluster (20 k€)
- (20k€) for the GPU-related task,
- 40k€ for communication and training actions
- overall requested budget (including 25% of overhead): 1 325 000 €

Participating and partner institutions

Participating beneficiary institutions:

- IJCLab Orsay (S. Barsuk, L.A. Couturier, Z. Conesa del Valle, C. Hadjidakis, V. Lafage, **J.P. Lansberg**, S. Lion, L. Massacrier)

- UC Louvain (C. Flett, T. Heimel, F. Maltoni, **O. Mattelaer**)

- INFN Cagliari (C. Flore, C. Puggioni, **C. Pisano**)

- WUT Warsaw (**D. Kikola**, J. Oleniacz, G. Wlazlowski)

Partner institutions:

AGH Krakow (P. Kotko)	INFN Perugia (M. Rinaldi)	RIKEN (N. Yamanaka)
Bergen U. (J. Nystrand)	Jagellonian U. (L. Motyka)	RUG Groningen (D. Boer)
CERN (D. d'Enterria, S. Roiser)	Jyvaskyla U. (V. Guzey, I. Helenius)	Santiago de C. U. (N. Armesto)
Heidelberg U. (T. Plehn)	Lancaster U. (V. Kartvelishvili)	Tubingen U. (M. Schlegel)
IFJ-PAN Krakow (A. Kusina, R. Ruiz)	LPTHE (H.S. Shao)	UC Dublin (R. McNulty, T. Kechadi)
IIHE Brussels (C. Van Hulse)	Lund U. (R. Frederix)	UC London (L. Harland-Lang)
INFN Bologna (D. Pagani)	Münster U. (M. Klasen, A. Kulesza)	
INFN Milan and Milan U. (M. Zaro, R. Winterhalder)	Penn State U. (A. Stasto)	

WP	Task	Title	Description	Total h.m	UCLAB (h.m)	UCLab people	Partner	WUT (h.m)	WUT people	Partner	UCLouvain (h.m)	UCLouvain people	Partner	CA (h.m)	CA people	Partner
WP1	T1.1	NLOAccess maintenance and consolidation	Maintenance of the database, of the cluster, of the security of the portal and of the cloud + software upgrade if hardware upgrade.	46	12	L.A. Couturier	CC IN2P3	16	D. Kikola		6	O.Mattelaer		12	C. Puggioni	
58	T1.2	Training, dissemination, communication and helpdesk activities	Helpdesk with ticket systems. Documentation on a wiki-like page. Training using the VA at Schools via off/online Master Classes. Note that dissemination actions are also understood for each activities.	12		J.P. Lansberg		3	D. Kikola		3	F. Maltoni		3	C. Pisano	
WP2	T2.1	Online access to MG7 + MG7NLO	Installation of MG7(NLO) on the NLOAccess cluster, verification of the performances, update of the user interface, upgrade of the user interface with new options offered compared to MG5.	12							6	O.Mattelaer		9	C. Flore	INFN-Bologna (D. Pagani) Lund (R. Frederix)
48	T2.2	Credential transfer	Investigation of a protocol to use e.g. the GRID/HPC credentials of NLOAccess users. Upgrade of the database and of the login page with higher security level. Implementation for a selected subset of users (e.g. IN2P3, INFN, CERN, ...).	6	2	S. Lion		2	J. Oleniacz		2	O.Mattelaer				
	T2.3	Software adaptation if credential transfer	Recompilation and possible adaptation of a selection of computing-intensive codes on NLOAccess to run on the GRID or other HPC facilities. Test with NNLO heavy-quark production codes.	3	3	V. Lafage										
	T2.4	MadNIS (neural network integrator) [https://madnis.ai/]	Implementation of the usage of the MadNIS (neural network sampling MC integrator) for quarkonium production in Madgraph at NLO	9							9	O.Mattelaer	INFN-Milan (R.Winterhalder), NIO (T. Plehn)			
	T2.5	Online access to GPU (MG7 + TMD evolution)	Interface to GPU facilities to run the GPU compliant version of MG5 online with optimised evolution code for TMD using FFT and PDF reweighting. Check of the code. Upgrade of the online interface. Investigation to port other codes.	18	3	V. Lafage	UCD (T. Kechadi)	6	G. Wlazlowski		7	O.Mattelaer	CERN (S. Roiser)	2	C. Puggioni	
WP3	T3.1	Starlight [https://github.com/STARlightsim/STARlight]	Inclusion of the Starlight MC code (ultra-peripheral collisions of relativistic ions).	9	2	L. Massacrier	UCD (R. McNulty)							7	C. Pisano	IIHE (C. Van Hulse)
36	T3.2	Exclusive lepto- and photo-production of quarkonia at NLO for EIC	Interface to two codes for exclusive production of quarkonia via resp. virtual and real photons at NLO using HEF. Code documentation. Test of a transparent interface to load GPD grids from the VA GPD Portal (ex Parton)	9	3	J.P. Lansberg		3	D. Kikola		3	C. Flett	IIHE (C. Van Hulse)	7	C. Pisano	Bergen U. (J. Nystrand)
	T3.3	SuperChic [https://superchic.hepforge.org/]	Inclusion of the SuperCHIC MC code (exclusive and photon-initiated production in proton and heavy ion collisions). Online interface to launch runs and dedicated output generation.	9	2	L. Massacrier	UCD (R. McNulty)						IIHE (C. Van Hulse)	7	C. Pisano	UCL London (L. Harland-Lang)
	T3.4	NLO code for high pt hadron & quarkonium production	Online interface for iNCNLO (a NLO code using NLL FF). Computation of quarkonium FF up to NLO in alpha_s and v^2. Document. Test of a transparent interface to FF from NPRF++ and input FF from the VA TMD Portal. Investigation of quarkonium FF studies at FCC-ee.	9	9	J.P. Lansberg							Lancaster (V.Kartvelishishvili), N. Yamanaka (RIKEN)			
WP4	T4.1	DIS in MG7 for EIC, LHeC & FCC-eh	Extension of MG7 to DIS processes at NLO (implementation, validation, tests, upgrade of the user interface, documentation)	12				6	D. Kikola + PhD student	IFJ Krakow (R. Ruiz)	6	F. Maltoni	UniM (M. Zaro), USC (N. Armesto)			
39	T4.2	Quarkonium in MG7 at NLO	Extension of MG7 to quarkonium production at NLO in NRQCD (currently achieved at LO). Creation of a library for virtual corrections to be used by other codes. Upgrade of the user interface to the quarkonium parameters.	15	4	J.P. Lansberg + PhD student	LPTHE (H.S. Shao)				6	F. Maltoni, C. Flett		3	C. Pisano	Lund (R. Frederix)
	T4.3	TMD hard scatterings using helicity-dependent amplitudes up to NLO in MG7	Extension of MG7 to use helicity-dependent amplitudes with NLO virtual corrections to generate hard scatterings at NLO in TMD factorisation with realistic TMD inputs to generate MC events (+ coupling to GPU computation of TMD evolution). Upgrade of the user interface. Documentation. Test of a transparent interface to load initial conditions for TMD evolution from the VA TMD Portal.	12	3	J.P. Lansberg	Groningen U. (D. Boer)				3	F. Maltoni		6	C. Pisano	Tübingen (M. Schlegel)
WP5	T5.1	Tool for automated online usage of diffractive PDFs via LHAPDF FOR LHC & EIC	Creation of an online tool to generate LHAPDF grids for diffractive PDFs and interface with MG7 and HO. Test, validation and documentation.	4	4	J.P. Lansberg	Jyvaskyla (V. Guzey)			IFJ Krakow (A. Kusina), Penn State (A.Stasto)						Münster (M. Klasen)
47	T5.2	Tool for automated online usage of resolved-photon PDFs for inclusive UPCs at LHC and ep collisions at LHeC & FCC-eh via LHAPDF	Creation of an online tool to generate LHAPDF grids for resolved-photon PDFs and interface with MG7 and HO for inclusive UPC computation up to NLO. Test, validation and documentation.	4	4	J.P. Lansberg	Jyvaskyla (V. Guzey)			IFJ Krakow (A. Kusina), Penn State (A.Stasto)						INFN-Perugia (M. Rinaldi)
	T5.3	Online tool for Pythia, Double Parton Scatterings and quarkonium production LHC, EIC & RHIC: tunes and colour reconnection effects	Online user interface to use Pythia tunes of NRQCD LDMEs on LHC and HERA quarkonium data to allow one to generate reliable MC quarkonium samples at the LHC, EIC & RHIC, including double parton scatterings. Interface via Pythia between LHE files and colour reconnection effects in quarkonium production. Documentation.	18	4	Z. Conesa del Valle, S. Barsuk	Jyvaskyla (I. Helenius), CERN (D. d'Enterria), LPTHE (H.S. Shao)	9	D. Kikola	IFJ Krakow (A. Kusina), JU (L. Motyka), Penn State (A.Stasto), Münster (A. Kulesza)	3	O.Mattelaer	IIHE (C. Van Hulse)			INFN-Perugia (M. Rinaldi)
	T5.4	Online interface to gamma-UPC (+ extension to single photon production) [http://hshao.web.cern.ch/hshao/gammaupc.html]	Online user interface to gamma-UPC in MG and HELAC-Onia. Documentation.	3	3	J.P. Lansberg				LPTHE (H.S. Shao), CERN (D. d'Enterria), UCD (R. McNulty & PhD student)						
	T5.5	Code and online interface for centrality-dependent cold nuclear matter effects in a Glauber MC for pp, AA and eA collisions	Interface between the asymmetric version of MG and a MC Glauber code reproducing the centrality selection of RHIC and LHC experiments to provide nuclear modifications factors for any hard probe in MG up to NLO (including parton shower and hadronisation at LO). A selection of the criteria used for the experimental centrality classes will be used and matched to an impact parameter distribution.	18	10	C. Hadjidakis	CERN (D. d'Enterria), LPTHE (H.S. Shao)	6	D. Kikola	IFJ Krakow (A. Kusina + PhD student)				2	C. Flore	
228				228	75			51						51		

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FCC-ee and FCC-hh D. d'Enterria (CERN)

Open Access, FAIR data management

- Results generated with NLOAccess should be published as Open Access
- Database of results
  - Option for users to store the generated results at the NLOAccess portal
  - Data will be managed according to FAIR principles (Findable, Accessible, Interoperable, Reusable)
  - The service could manage:
    - Input data submitted by users (configuration files).
    - Output data from computations (numerical results, plots).
    - Metadata describing the computations
    - Logs and other information needed for reproducibility.
  - Data will be made openly accessible through a web portal, subject to user consent. Published results and datasets will be released under Creative Commons (with the specific level selected by the author)
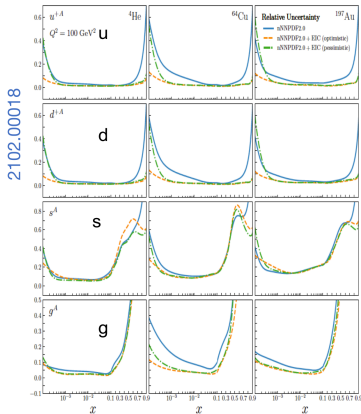
Partners

Gantt chart
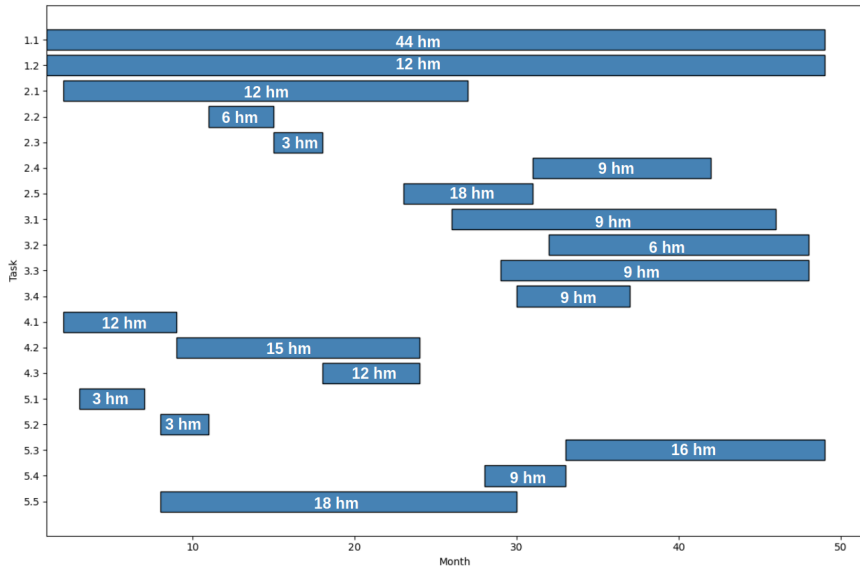
Kinematic planes for nuclei

2102.00018

2407.13058, γ@ALICE FoCal

- Large impact from EIC.
- Sizable impact from LHCb SMOG2 and ALICE FoCal (γ's ∼ D's).

2503.21531 LHCb SMOG2

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