
Curriculum vitae and track record

16/06/2026

Personal details

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Education and key qualifications

03/07/2017 PhD in Physics, University of Antwerp, Belgium,
Quantum Chromodynamics at small Bjorken-x, PhD advisor: Pierre Van Mechelen

2013 Master in Physics (magna cum laude), University of Antwerp and Free University of Brussels, Belgium,
Computation of the Chern-Simons diffusion rate using the gauge/gravity correspondence,
thesis advisor: Ben Craps

Current positions

2026 Part-time professor (10%), Department of Physics, University of Antwerp, Belgium

2026 Postdoctoral researcher, Université Paris-Saclay, IJCLab, Orsay, France

Previous positions

2021-2025 Senior postdoctoral position from the Research Foundation Flanders (FWO),
personal grant no. 1233422N, Department of Physics, University of Antwerp, Belgium

2019-2021 Postdoctoral researcher/teaching assistant (chargé d'enseignement), Center of Theoretical Physics (CPHT),
Ecole Polytechnique, France

2018-2019 Postdoctoral researcher with National Institute of Nuclear Physics (INFN) for foreigners grant, Depart-
ment of Physics, University of Cagliari, Italy

2017-2018 Postdoctoral researcher in the context of the 3DSpin ERC grant, National Institute of Nuclear Physics
(INFN), Department of Physics, University of Pavia, Italy

Long-term research visits

2017 Visitor in the Department of Particle Theory in IFJ PAN, Poland, with Krzysztof Kutak (four months)

2016 Internship in the Center of Theoretical Physics of Ecole Polytechnique, France, with Cyrille Marquet
(five months)

2015-2016 Internship in the Center of Theoretical Physics in CEA Saclay, France, with Edmond Iancu (six months)

Long-term career breaks

07-09/2024 Parental leave (three months)

05/2022 Parental leave (one month)

Research statement

Since starting my PhD thesis in 2013, I have forged my research path independently because I was interested in pursuing a theoretical topic although being part of an experimental particle physics group. My PhD advisor, Pierre Van Mechelen (CMS Collaboration), supported me in this and stimulated me to build an international network of collaborations. During postdoc positions at the universities of Pavia and Cagliari, as well as in Ecole Polytechnique and my present position at the University of Antwerp, I have established two major research lines in which I have become a leading expert. The overarching research topic is the gluon structure of the proton in three-dimensional momentum space. Due to confinement, this structure is out of reach of direct perturbative calculations, but can

be parameterized in gluon Transverse Momentum Distribution functions (gluon TMDs) which need to be extracted from experimental data. However, due to the theoretical and experimental complexity of doing so, they remain completely unknown,¹ even though they are critical components in the mass- and spin composition of the proton.

The first research topic is on studying gluon TMDs with the help of quarkonia, i.e., bound heavy-quark states. The latter are promising probes since they couple to the gluon distribution of the proton already at the leading order in the strong coupling. I was introduced to this subject by Cristian Pisano (U. Cagliari) during my PhD, whom I assisted in the theoretical calculations of quarkonium hadroproduction within a QCD-inspired model [11,15]. During my postdocs in Pavia and Cagliari, I further explored this idea by applying it to quarkonium production in polarized deep-inelastic scattering (DIS), which will be measured at the future Electron-Ion Collider. The results were published in refs. [9,10], for which I performed all the calculations myself, with C. Pisano and me writing the papers and the more senior researchers giving advice. In Cagliari, we turned to the fundamental question of the rigorous QCD factorization of quarkonium leptonproduction, i.e., whether our results in [9,10] are robust when including radiative corrections. This question is closely related to the very complex problem of disentangling soft gluon radiation in the formation of the bound state from Sudakov gluon radiation associated with the gluon TMD. Together with Daniël Boer (U. Groningen), we devised an indirect way to perform this disentanglement using a TMD-collinear matching procedure [7]. C. Pisano and I shared the work of performing the calculations and writing the paper, again advised by the more senior experts. To tackle this problem in a more direct and systematic way, I started learning soft-collinear effective theory (SCET) and non-relativistic QCD (NRQCD) with the help of Miguel Echevarria (Basque U., Bilbao). Together with him and his PhD student Samuel Romera, we managed to establish a rigorous factorization theorem for single-inclusive quarkonium production in DIS and explicitly validate it at one-loop level [1]. I performed the calculations in SCET while S. Romera computed the NRQCD diagrams, and we checked each other results; the paper was written by the three of us. At present, we are studying back-to-back double J/ψ production in proton-proton collisions, for which experimental data from the LHC is available. In this project, I perform the analytical one-loop calculations, S. Romera works on the numerical calculations and the fit, while experts M. Echevarria and J.-P. Lansberg (IJCLab, Orsay) provide guidance.

The second subject is related to QCD at high energies, or equivalently, small momentum fractions x , where the highly dense gluon fields dominate the scattering dynamics. This kinematical region of QCD, where the nonlinear effects of gluon saturation can become important, is described by the Color Glass Condensate (CGC) effective field theory. Not suprisingly, collider experiments which probe this regime of QCD can be very sensitive to gluon TMDs. During my PhD, I spent half a year in CEA Saclay to study the CGC with Edmond Iancu, one of its founders, and made my first contribution while interning with Cyrille Marquet (Ecole Polytechnique). Under the guidance of the latter, I performed the analytical calculations and numerical simulations on gluon TMDs in heavy-quark hadroproduction in the CGC, which we published in [14]. I became fascinated by the possibility of a much deeper connection between the CGC and gluon TMDs than previously thought. This connection would yield new pathways to understanding saturation, and I became determined to investigate it at next-to-leading order (NLO) in perturbation theory. At that time, however, no available NLO calculation in the CGC was relevant to test my hypothesis. Moreover, the theoretical machinery to extend the CGC-TMD connection beyond the lowest perturbative order did not yet exist. I convinced C. Marquet, together with Renaud Boussarie (Ecole Polytechnique) and Tolga Altinoluk (NCBJ, Warsaw), whom I met during a four-month internship in Krakow, to join me in a quest to answer these complicated questions. Our first two works were studies of processes with three outgoing particles. Such processes are the ‘real’ radiation part of NLO calculations and require extending the existing techniques to study TMDs in the CGC. I performed the calculations with T. Altinoluk, cross-checking each other’s results and writing the papers [8,12] together while discussing the conceptual problems with C. Marquet and R. Boussarie during visits to Paris and Warsaw. Having arrived at Ecole Polytechnique for a two-year postdoctoral position, I turned to the problem of including subleading-power corrections into the formalism, still calculating and writing together with T. Altinoluk, with C. Marquet in an advisory role [4]. After these preparatory works, I performed the full NLO calculation of the production of two back-to-back jets in photon-proton or photon-nucleus collisions in the CGC, which will be measured in the future Electron-Ion Collider. I then demonstrated how to identify Sudakov radiation, the crucial ingredient of gluon TMDs at higher orders, and disentangle it from the saturated gluon condensate. The breakthrough was the realization that the commonly used approach to nonlinear low- x evolution (BK-JIMWLK) needs to be adapted to be consistent with Sudakov resummation. I performed the large majority of the calculations and wrote the paper [3], receiving help on key issues from Guillaume Beuf (NCBJ Warsaw), who is an expert on NLO computations in the CGC. In a follow-up work [2], I performed the NLO calculation in the CGC of Drell-Yan plus jet production. This is the first NLO CGC calculation that is at the same time relevant for the Large Hadron Collider and sensitive to gluon TMDs.

¹Somewhat aside from my main research, I coauthored a highly cited paper [6] on models for gluon TMDs, a study which I initiated and where I performed the analytical calculation. The numerical work and most of the writing were done by F. C. Celiberto (Alcala U., Madrid).

Publication list

At the time of writing, I have 18 papers where I am a principal author and which are published in high-impact international journals with peer review. Excluding self-citations, defined as any citation by at least one of the coauthors, the metrics on INSPIRE-HEP indicate a total of 632 citations on 16/06/26. As someone whose name starts with a ‘T’, I must point out that in high-energy physics, the standard practice is to list the authors alphabetically, and there is no notion of ‘first author.’ This rule is only deviated from in exceptional circumstances to strongly emphasize the main authorship, such as in [3]. My complete publication list, including works with more than five authors or conference proceedings, can be consulted on INSPIRE-HEP.

- [1] M.G. Echevarria, S.F. Romera, and P. Tael, *Factorization for J/ψ leptonproduction at small transverse momentum*, JHEP 09 (2024) 188; 16 citations
- [2] P. Tael, *Forward production of a Drell-Yan pair and a jet at small x at next-to-leading order*, JHEP 01 (2024) 005; 26 citations
- [3] P. Tael, T. Altinoluk, G. Beuf, and C. Marquet, *Dijet photoproduction at low x at next-to-leading order and its back-to-back limit*, JHEP 10 (2022) 184; 106 citations
- [4] T. Altinoluk, C. Marquet, and P. Tael, *Low- x improved TMD approach to the lepto- and hadroproduction of a heavy-quark pair*, JHEP 06 (2021) 085; 35 citations
- [5] D. Boer, C. Pisano, and P. Tael, *Extracting color octet NRQCD matrix elements from J/ψ production at the EIC*, Phys. Rev. D 103 (2021) 7, 074012; 22 citations
- [6] A. Bacchetta, F. G. Celiberto, M. Radici, and P. Tael, *Transverse-momentum-dependent gluon distribution functions in a spectator model*, Eur. Phys. J. C 80 (2020) 8, 733; 130 citations
- [7] D. Boer, U. D’Alesio, F. Murgia, C. Pisano, and P. Tael, *J/ψ meson production in SIDIS: matching high and low transverse momentum*, JHEP 09 (2020) 040; 48 citations
- [8] T. Altinoluk, R. Boussarie, C. Marquet, and P. Tael, *Photoproduction of three jets in the CGC: gluon TMDs and dilute limit*, JHEP 07 (2020) 143; 46 citations
- [9] A. Bacchetta, D. Boer, C. Pisano, and P. Tael, *Gluon TMDs and NRQCD matrix elements in J/ψ production at an EIC*, Eur. Phys. J. C 80 (2020) 1, 72; 72 citations
- [10] U. D’Alesio, F. Murgia, C. Pisano, and P. Tael, *Azimuthal asymmetries in semi-inclusive J/ψ + jet production at an EIC*, Phys. Rev. D 100 (2019) 9, 094016; 76 citations
- [11] U. D’Alesio, C. Flore, F. Murgia, C. Pisano, and P. Tael, *Unraveling the gluon Sivers functions in hadronic collisions at RHIC*, Phys. Rev. D 99 (2019) 3, 036013; 70 citations
- [12] T. Altinoluk, R. Boussarie, C. Marquet, and P. Tael, *TMD factorization for dijets + photon production from the dilute-dense CGC framework*, JHEP 07 (2019) 079; 38 citations
- [13] E. Iancu, P. Tael, and B. Wu, *Jet quenching parameter in an expanding QCD plasma*, Phys. Lett. B 786 (2018) 288; 25 citations
- [14] C. Marquet, C. Roiesnel, and P. Tael, *Linearly polarized small- x gluons in forward heavy-quark pair production*, Phys. Rev. D 97 (2018) 1, 014004; 78 citations
- [15] U. D’Alesio, F. Murgia, C. Pisano, and P. Tael, *Probing the gluon Sivers function in $p^\uparrow p \rightarrow J/\psi X$ and $p^\uparrow p \rightarrow DX$* , Phys. Rev. D 96 (2017) 3, 036011; 86 citations
- [16] I.O. Cherednikov, J. Lauwers, and P. Tael, *On a Wilson line approach to the study of jet quenching*, Eur. Phys. J. C 74 (2014) 2721; 13 citations
- [17] T. Mertens and P. Tael, *Evolution of light-like Wilson loops with a self-intersection in loop space*, Phys. Lett. B 727 (2013) 563; 12 citations
- [18] B. Craps, C. Hoyos, P. Surowka, and P. Tael, *Chern-Simons diffusion rate in a holographic Yang-Mills theory*, JHEP 11 (2012) 109, JHEP 02 (2013) 087 (erratum); 14 citations

Talks on international conferences

10/06/2026: invited talk, *Double J/ψ production as a probe of gluon TMDs*, Synergies between the EIC and the LHC, Cagliari, Italy

08/01/2025: invited talk, *Factorization for J/ψ leptonproduction at small transverse momentum*, Quarkonia as Tools, Aussois, France

12/04/2024: invited plenary talk, *Summary of WG2: Small- x , Diffraction and Vector Mesons*, (with Renaud Boussarie and Cristian Baldenegro), 31st International Workshop on Deep Inelastic Scattering and Related Subjects (DIS2024), Grenoble, France

15/01/2024: invited talk, *Towards NLO for forward Drell-Yan production at small transverse momentum in the CGC*, Workshop on overlap between QCD resummations, Aussois, France

15/05/2023: invited talk, *Back-to-back dijet photoproduction at NLO in the CGC*, CGC at the EIC, ECT* Trento, Italy

17/11/2022: invited talk, *Back-to-back dijet photoproduction at NLO in the CGC*, Saturation at the EIC, Paris, France (remote)

15/11/2022: invited talk, *Gluon transverse distributions and saturation*, MPI@LHC 2022: 13th International workshop on Multiple Partonic Interactions at the LHC, Madrid, Spain (remote)

02/11/2022: invited talk, *Sudakov logarithms in dijet photoproduction at low x* , REF2022: Resummation, Evolution, Factorization 2022 (remote)

19/10/2022: talk, *Forward heavy-flavor production in $p+A$ as a probe of gluon polarization and parton saturation*, HF2022: Heavy Flavours from small to large systems, Paris, France (remote)

12/01/2022: invited talk, *Shape functions: ep and pp* , Quarkonium as Tools, Aussois, France

08/10/2021: invited plenary talk, *Hadronic physics at the Electron Ion Collider*, QCD Structure of the Nucleon (QCD-N2021), Alcalà de Henares, Spain

13/04/2021: talk, *Quarkonium production and gluon TMDs at the EIC*, 28th International Workshop on Deep Inelastic Scattering and Related Subjects (DIS 2021), Stony Brook, USA (remote)

24/03/2021: invited talk, *Gluon TMDs and quarkonium production at the EIC*, virtual Quarkonium as Tools, France (remote)

26/01/2021: invited talk, *Quarkonium production and gluon TMDs at the EIC*, EIC opportunities for SnowMass, USA (remote)

10/01/2021: invited plenary talk, *Connections between the CGC and transverse momentum distributions*, Initial Stages, Rehovot, Israel (remote)

16/12/2020: invited talk, *Gluon TMDs in electroproduction of quarkonium*, SnowMass EF06-RF07 Joint meeting, USA (remote)

15/01/2020: invited talk, *J/ψ and J/ψ +jet lepton production: what to expect from the EIC*, Quarkonia as Tools, Aussois, France

28/11/2019: invited talk, *Photoproduction of three jets in TMD factorization from the CGC*, Workshop on Resummation, Evolution, Factorization (REF 2019), Pavia, Italy

10/07/2019: invited talk, *Gluon TMDs in J/ψ +jet production at an EIC*, Sardinian Workshop on Spin studies, Cagliari, Italy

9/04/2019: talk, *Gluon TMDs in quarkonium production at an EIC*, 17th International Workshop on Deep Inelastic Scattering and Related Subjects (DIS 2019), Turin, Italy

17/01/2019: invited talk, *Probing gluon TMDs in J/ψ hadro- and electroproduction*, Quarkonia as Tools workshop, Aussois, France

21/11/2018: invited talk, *Gluon TMDs from the Color Glass Condensate*, Workshop on Resummation, Evolution, Factorization (REF 2018), Krakow, Poland

29/08/2018: invited talk, *Gluon TMDs and NRQCD matrix elements in J/ψ and Υ production at an EIC*, Diffraction and low- x , Reggio di Calabria, Italy

24/05/2018: talk, *Gluon TMDs from $pA \rightarrow$ dijet + photon in the CGC*, Probing QCD at the high energy frontier, ECT*, Trento, Italy

16/11/2017: talk, *Linearly polarized small- x gluons in forward heavy-quark production*, Workshop on Resummation, Evolution, Factorization (REF 2017), Universidad Complutense de Madrid, Spain

5/12/2016: talk, *Heavy quark production in unpolarized eA and pA scattering: the role of gluon polarization*, Workshop on QCD and Diffraction (Saturation 1000+), Krakow, Poland

10/11/2016: invited talk, *Heavy quark production in unpolarized eA and pA scattering: the role of gluon polarization*, Workshop on Resummation, Evolution, Factorization (REF 2016), University of Antwerp, Belgium

3/06/2016: talk, *The high-energy evolution of the jet quenching parameter*, QCD Evolution 2016, NIKHEF, The Netherlands

3/03/2016: invited talk, *Quarkonium production in the CGI-GPM model*, New Observables in Quarkonium Production, ECT* Trento, Italy

4/12/2014: invited talk, *Jet quenching in a Wilson line formalism*, International Workshop on Frontiers of QCD, IIT Bombay, India

Research seminars

20/05/2025: *Interplay between transverse-momentum dependent factorization and quarkonium formation*, Laboratoire de Physique des 2 Infinis, IJCLab, Orsay, France

19/11/2021: *Quarkonium production at the EIC as a probe of gluon TMDs*, BNL Nuclear Theory Group seminar, Brookhaven National Laboratory, USA (remote)

28/01/2021: *Gluon TMDs from quarkonium production at the EIC*, IFJ PAN, Krakow, Poland (remote)

15/06/2020: *Gluon TMDs in electroproduction*, JLAB theory seminar, Thomas Jefferson National Accelerator Facility, USA (remote)

6/06/2018: *Gluon TMDs from forward processes in the CGC*, Department of physics, University of Cagliari, Italy

25/01/2018: *Linearly polarized small- x gluons in forward heavy-quark production*, Department of physics, Universidad de Santiago de Compostela, Spain

8/11/2017: *Gluon TMDs at small Bjorken- x* , Department of physics, University of Pavia, Italy

18/10/2017: *Linearly polarized small- x gluons in forward heavy-quark production in pA collisions*, Theoretical physics division, National Centre for Nuclear Research, Warsaw, Poland

11/07/2017: *Heavy-quark production in non-polarized proton-nucleus collisions: the role of gluon polarization*, IFJ PAN, Krakow, Poland

Talks on national conferences

29/01/2020: *Gluon TMDs in electroproduction*, Rencontres de Physique des Particules 2020, Ecole Polytechnique, France

29/09/2016: *Heavy quark production in unpolarized eA and pA scattering: the role of gluon polarization*, Meeting de lancement GDR QCD - Interactions simples et multiples entre partons dans les nucléons, IPN Orsay, France

22/05/2015: *Jet quenching in a Wilson line formalism*, ‘Theory at Sea’ Flemish theorists meeting, Oostende, Belgium

9/04/2013: *Working with Wilson lines: SCET*, ‘Theory at Sea’ Flemish theorists meeting, Oostduinkerke, Belgium

Other contributions to the research community

I regularly conduct peer reviewer for Physics Letters B and Physical Review D, two of the leading journals in our field. I was a convener for the Quarkonia as Tools workshop in 2026, as well as for the *Small- x , diffraction and vector mesons* working group during DIS 2024. Moreover I am regularly assisting in outreach activities, such as the European Researcher’s Night, masterclasses Hands on Particle Physics, the Belgian physics and mathematics olympiads, and the Fusion Show.

Teaching experience

2021: 52 contact hours as an assistant for the course *Thermodynamics and statistical physics*, Prof. Dr. L. Sanchez-Palencia, 3th bachelor, Ecole Polytechnique

2020: 26 contact hours as an assistant for the course *Thermodynamics and statistical physics*, Prof. Dr. L. Sanchez-Palencia, 3th bachelor, Ecole Polytechnique

2020: 18 contact hours as an assistant for the course *Mathematical methods for physics II*, Prof. Dr. B. Goutéraux, 1st bachelor, Ecole Polytechnique

2014-2017: 56 contact hours as an assistant for the course *Subatomic physics*, Prof. Dr. P. Van Mechelen, 3rd bachelor, University of Antwerp

2014-2016: 34 contact hours as an assistant for the course *Relativity and particle physics*, Prof. Dr. P. Van Mechelen, 2nd bachelor, University of Antwerp

2013-2014: 10 contact hours as a lecturer for the course *Capita Selecta: Advanced Quantum Field Theory*, Prof. Dr. P. Van Mechelen and Dr. I. O. Cherednikov, 1st and 2nd master, University of Antwerp

Supervision

Also at the University of Antwerp, I have supervised six bachelor’s theses. I find great satisfaction in making these theses interesting for both the students and me, either by proposing original research topics that are in principle far beyond bachelor level (*Higher-order corrections to Delbrück scattering*), or else subjects that are new to me (*Instantons in quantum mechanics*, *Solitons*, *Static quark-antiquark potential in lattice QCD*). In all these cases, I am challenged to study unfamiliar topics and devise a way to, in weekly meetings, explain them to my students. At present, I am supervisor for two master theses.

2025-: *Bound states in QCD*, M. Peremans; *QCD equation of state from the lattice*; J. Pinchuk (co-supervision with Benjamin Jäger, University of Southern Denmark)

2024-2025: *Building a parton shower*, B. Laurent

2023-2024: *Foton-foton verstrooiing*, L. De Broe; *Light-by-light scattering*, X. Decleyre

2014-2015: *Een studie omtrent solitonen*, S. Kuppens; *Lattice QCD berekening van de statische quark-antiquark potentiaal*, N. Francken

2013: *Instantonen en tunnelingsprocessen in de kwantummechanica*, J. Sanctorum

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