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Curriculum Vitae

Sonia Carrà

March 22, 2024

Current position

Since Feb. 2022 **Post-doc at INFN Sezione di Milano, ATLAS experiment group**
Convener of the ATLAS group for the search of electroweak Supersymmetry.
Working on search for beyond the Standard Model physics at the LHC and on upgrade of the ATLAS inner tracker (ITk) for the High Luminosity LHC.

Past positions

Feb. 2019 - Jan. 2022 **Research fellow** at DESY Hamburg, ATLAS experiment group.
Jan. 2018 - Dec. 2018 **CERN Associate**, INFN scholarship for Cooperation Associate position.
Oct. 2015 - Jan. 2019 **PhD student** at University of Milano, Department of Physics.
May 2015 - Sep. 2015 **Postgraduate scholarship** at University of Pavia, Department of Physics, for MicroMegas prototyping.

Education

Oct. 2015 - Jan. 2019 **PhD in Physics, Astrophysics and Applied Physics**, University of Milano
Thesis title: *Search for electroweak production of supersymmetric particles at the LHC Run 2 with the ATLAS detector*
Supervisor: Dr. Tommaso Lari

Jun. - Jul. 2018 **European School of High-Energy Physics**, organized by CERN and JINR, Maratea, Italy

- Mar. 2013 - Apr. 2015 **Master's degree in Nuclear and Subnuclear Physics**, University of Pavia
Thesis title: *Projection for the search of the top squark with two lepton in the final state with the ATLAS detector at the LHC Run 2*
Supervisor: Dr. Giacomo Polesello
Grade: 110/110
- Oct. 2009 - Feb. 2013 **Bachelor's degree in Physics**, University of Pavia
Thesis title: *Double beta decay without emission of neutrinos*
Supervisor: Prof. Claudio Conta
Grade: 100/110

Leadership and responsibilities

- Sep. 2023 - present **Convener of the ATLAS group for the search for electroweak Supersymmetry (SUSY)**
The group is dedicated to the search of Supersymmetric particles with electroweak production. My task involves the coordination and review of the related research activities, currently consisting in about 10 analyses (about 100 people) dedicated to different processes and signatures. I also take part in the definition of the future research program of the group and the target of the novel LHC Run 3 analyses.
- Apr. 2019 - Jul. 2023 **Analysis team leader for the ATLAS search for electroweakinos and sleptons with moderately compressed mass spectra**
As team leader of this full Run 2 ATLAS analysis, I coordinated the team, I supervised the students and I was editor of the paper. The analysis team consisted of about 15 people from several institutes based in Germany, Italy, UK, Norway and Switzerland. Together with the team leader duties I also developed the search, working at the analysis framework maintenance, identification of discriminating kinematic variables between the searched signal and the background sources, and providing the theory uncertainties estimate. The results have been published as paper by the Journal of High Energy Physics [Paper, 4].
- Jul. 2022 - Feb. 2024 **Editorial board member for the search for pair production of squarks or gluinos with leptonic signature**
I have been appointed member of the reviewing committee of the Supersymmetry analysis searching for the pair production of squarks or gluinos, decaying via sleptons or weak bosons in final states with two same-sign or three leptons, performed with the data collected by the ATLAS detector during LHC Run 2. The paper has been published by the Journal of High Energy Physics [Paper, 2].
- Sep. 2019 - Dec. 2021 **Internal reviewer for the ATLAS Supersymmetry group**
Given my expertise on SUSY searches, I was appointed ATLAS internal reviewer for the SUSY group for two analyses targeting electroweak SUSY models with a three leptons signature. The papers were published by the European Physics Journal C and the Journal of High Energy Physics [Papers, 7 and 11].

Aug. 2019 - Oct. 2021 **HEP-data contact for the ATLAS Supersymmetry group**
I was in charge of the review of the reinterpretation material provided by the analysis team, used in the wider particle physics community to test the ATLAS Supersymmetry searches against alternative new physics models. I reviewed over 20 papers, the most relevant ones are listed in the Publication section [Papers, [8](#), [9](#), and [13](#)].

Research activity

Search for beyond Standard Model physics

- 2022 - present **Search for Higgsino with displaced track**
Using the full ATLAS Run 2 dataset, I developed a novel search for Higgsino particles in the scenario of a very compressed Supersymmetric mass spectrum. The signature of interest is a track originated from the pion from the Higgsino decay and missing transverse momentum.
I was strongly involved in the development of the analysis strategy, I produced and validated the Monte Carlo simulation for the Supersymmetry model and I supervised the students. The paper presenting the result has been submitted to the Physical Review Letters [Paper, [1](#)].
- 2019 - 2022 **Search for electroweakinos and sleptons with moderately compressed mass spectra**
I personally developed the search for charginos and sleptons direct production considering a dileptonic signature, aiming to explore Supersymmetric particles with moderately compressed mass spectrum using the full ATLAS Run 2 dataset.
In addition to serving as analysis team leader and editor of the paper, I also worked at the analysis framework maintenance, I identified discriminating kinematic variables and I provided the theory uncertainties estimate. The result has been published as paper by the Journal of High Energy Physics [Paper, [4](#)].
- 2020 - 2021 **Search for axion-like particles based on recasting of published WW cross section measurements**
I worked at the search for axion-like particles (ALPs) base on the reinterpretation of ATLAS Run 2 differential cross section measurements. I performed the reinterpretation of the $WW+0$ jets and WW +jets measurements, including the validation of the axion-like particles Monte Carlo simulation, the study of the kinematic of the process and the statistical interpretation. The result was published by the Physical Review D journal [Paper, [5](#)].

- 2017 - 2019 **Search for charginos direct production with W mediated decay**
Exploiting the 2015-2017 ATLAS dataset, I designed the search for charginos direct production with W mediated decay. I maintained the analysis framework, identified the discriminating kinematic variables, validated the data and Monte Carlo simulation, provided the systematic uncertainties estimate and performed the statistical interpretation.
The results were published as conference note for the SUSY 2018 conference [Conf. note, [1](#)]. I then worked to enhance the analysis using the full Run 2 luminosity, and the result was published by the European Physical Journal C [Paper, [10](#)].
- 2018 - 2019 **SUSY searches at the High-Luminosity LHC**
I worked at future prospects for the SUSY searches at the High-Luminosity LHC, considering production of charginos with W boson mediated decay. I studied the feasibility of the analysis and its expected sensitivity, and the results were published in the *Report on the Physics at the HL-LHC* [Paper, [12](#)].
- 2016 - 2017 **Search for sleptons with 2 leptons signature**
I was the developer of a slepton search with two lepton and missing transverse momentum signature, using the Run 2 36 fb^{-1} dataset collected by the ATLAS detector. I designed most aspect of the analysis, including the identification of discriminating kinematic variables, the background estimate and the associated systematic uncertainties, and I performed the statistical interpretation of the results. The search was published by the European Physical Journal C [Paper, [14](#)].
- 2015 - 2016 **Search for top squark direct production with 2 leptons final state**
I was the main analyser of a search aiming for the observation of top squark production, with a two leptons and jets signature, using the Run 2 13.3 fb^{-1} dataset collected by the ATLAS detector. I took care of most aspects of the analysis: identification of discriminating kinematic variables, comparison between data and Monte Carlo simulation, theory uncertainties estimate and statistical interpretation of the result. I was also the editor of the supporting note. The result was published as conference note for ICHEP 2016 [Conf. note, [2](#)].
Exploiting my expertise with the signature, I also contributed to the top squark search with 36 fb^{-1} , providing the estimate of the theory uncertainties and validating the result [Paper, [15](#)].

Contribution to Standard Model measurements

- 2021 - 2022 **Measurement of WW differential cross section in Supersymmetry inspired topologies**
The regions defined in the paper for the search of charginos direct production with W mediated decay [Paper, [10](#)] were further used to measure the WW differential cross section in a topology close to a Supersymmetric signature. I maintained the analysis framework and I validated the results. The WW differential cross section measurement was published by European Physical Journal C [Paper, [3](#)].

2020 - 2021 **Reinterpretation study for WW +jets measurements**

In parallel to the work on the reinterpretation of Standard Model measurements for a physics model predicts axion-like particles (ALPs) [Paper, 5], I collaborated with the ATLAS Standard Model WW +jets team to provide studies on the kinematic variables more sensitive to new physics phenomena, considering both Supersymmetric particles and axion-like particles [Paper, 6].

Detector upgrade and operation

2022 - present **ATLAS detector upgrade - cooling system for the ITk Pixel detector**

I work at the upgrade of the ATLAS inner tracking system (ITk) that will be installed for the High Luminosity LHC, to replace the existing tracking detector. In particular I work at the prototyping and construction of the cooling system for the pixel endcap detector. The Pixel silicon sensors will need to operate at a temperature of -35°C , in order to avoid the reverse annealing, control the leakage current due to radiation damage and avoid the detector thermal runaway. The cooling system is based on CO_2 due to its efficiency and radiation hardness, and the capability to operate in reduced diameters pipe, giving a small impact on the material budget of the system.

I'm strongly involved in the assembly and testing of prototypes of the cooling system, in order to finalized the detector design and ensure compliance to specifications. The tests are performed both in Milano with a TRACI multipurpose CO_2 cooler and at CERN at the CO_2 cooling plant BabyDemo. I'm in charge of the data taking, I performed the data analysis and I presented the results to the ATLAS Collaboration and at international conferences. I also perform the quality control on the cooling system components built in the Milano workshop.

2019 - 2022 **Module assembly for the ITk strip detector**

I worked at the module assembly of the strip endcap detector for the ATLAS ITk. I equipped the silicon strip detectors with readout electronics and I commissioned the glue dispensing robot that is used for the assembly. I performed quality checks on the assembled modules, using both microscopes and smartscopes.

I also strongly contributed to the coordination of the DESY module assembly team and to the effort for the qualification of DESY Hamburg as production site. I also served as *clerk* for the DESY cluster, reporting on the activities of the sites to the ATLAS Collaboration.

2015 - 2018 **Pixel detector operations**

I was part of the ATLAS Pixel sub-detector group, I took care of the improvement and periodic quality check of the charge calibration of the Pixel detector. I was also an ATLAS control room shifter for the Inner Detector desk.

Teaching

- 2022/23 - 2023/24 Teaching assistant for the course of *Numerical methods for experimental data analysis* (*Laboratorio di trattamento numerico dei dati sperimentali*), at University of Milano, Department of Physics, for a total of 36 hours for each academic year.
- 2016/17 - 2017/18
- 2022/23 - 2023/24 Teaching assistant for the course of *Physics laboratory with introduction to statistics* (*Laboratorio di fisica con elementi di statistica*), at University of Milano, Department of Physics, for a total of 60 hours for each academic year.

Mentoring

- 2022 - present Mentoring of PhD student Alessandro Sala (University of Milano) on the search for higgsinos Supersymmetric particles at the LHC with the ATLAS detector.
- 2021 - 2022 Mentoring of PhD student Vincent Goumarre (DESY and University of Freiburg) on study on the constraint on axion-like particles.
- 2020 - 2021 Mentoring of PhD student Hamish Teagle (DESY and University of Liverpool) on the search for bottom squark at the LHC with the ATLAS detector.
- 2019 - 2022 Mentoring of PhD student Jorge Andres Sabater Iglesias (DESY and University of Freiburg) on the search for sleptons Supersymmetric particles at the LHC with the ATLAS detector.
- 2019 - 2022 Mentoring of PhD student Alessia Renardi (DESY and University of Dortmund) on the modules assembly for the ITk strip endcap detector.
- 2019 Supervision of DESY summer student Veronika Kratzer on a project targeting the estimation of the sensitivity of current SUSY searches to pMSSM inspired models.

Publications

As part of the ATLAS Collaboration, I published over 700 papers. The full publication list can be found at <https://orcid.org/0000-0001-8650-942X>.

A list of my selected publications, in chronological order, is reported in this section. A separated document reports the publication list reduced to 12 entries and my personal contribution to each paper.

Papers:

1. ATLAS Collaboration, *Search for nearly mass-degenerate higgsinos using low-momentum mildly-displaced tracks in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector*, arXiv:2401.14046 [hep-ex], submitted to PRL
2. ATLAS Collaboration, *Search for pair production of squarks or gluinos decaying via sleptons or weak bosons in final states with two same-sign or three leptons with the ATLAS detector*, JHEP

- 02 (2024) 107, arXiv:2307.01094 [hep-ex]
3. ATLAS Collaboration, *Measurements of W^+W^- production in decay topologies inspired by searches for electroweak supersymmetry*, Eur. Phys. J. C 83 (2023) 718, arXiv:2206.15231 [hep-ex]
 4. ATLAS Collaboration, *Search for direct pair production of sleptons and charginos decaying to two leptons and neutralinos with mass splittings near the W -boson mass in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS detector*, JHEP 06 (2023) 031, arXiv:2209.13935 [hep-ex]
 5. S. Carrà, V. Goumarre, R. Gupta, S. Heim, B. Heinemann, J. Kuechler, F. Meloni, P. Quilez, and Y.-C. Yap, *Constraining off-shell production of axionlike particles with $Z\gamma$ and WW differential cross-section measurements*, Phys. Rev. D 104 (2021) 092005, arXiv:2106.10085 [hep-ex]
 6. ATLAS Collaboration, *Measurements of $W^+W^- + \geq 1$ jet production cross-sections in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector*, JHEP 06 (2021) 003, arXiv:2103.10319 [hep-ex]
 7. ATLAS Collaboration, *Search for chargino–neutralino pair production in final states with three leptons and missing transverse momentum in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS detector*, Eur. Phys. J. C 81 (2021) 1118, arXiv:2106.01676 [hep-ex]
 8. ATLAS Collaboration, *Search for Displaced Leptons in $\sqrt{s} = 13$ TeV pp Collisions with the ATLAS Detector*, Phys. Rev. Lett. 127 (2021) 051802, arXiv:2011.07812 [hep-ex]
 9. ATLAS Collaboration, *Search for squarks and gluinos in final states with jets and missing transverse momentum using 139 fb^{-1} of $\sqrt{s} = 13$ TeV pp collision data with the ATLAS detector*, JHEP 02 (2021) 143, arXiv:2010.14293 [hep-ex]
 10. ATLAS Collaboration, *Search for electroweak production of charginos and sleptons decaying into final states with two leptons and missing transverse momentum in $\sqrt{s} = 13$ TeV pp collisions using the ATLAS detector.*, Eur. Phys. J. C 80 (2020) 123, arXiv:1908.08215 [hep-ex]
 11. ATLAS Collaboration, *Search for chargino–neutralino production with mass splittings near the electroweak scale in three-lepton final states in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS detector*, Phys. Rev. D 101 (2020) 072001, arXiv:1912.08479 [hep-ex]
 12. S. Carrà, T. Lari, D. L. Noel, C. Potter, *Section Chargino pair production at HL-LHC in A. Dainese, M. Mangano, A. B. Meyer, A. Nisati, G. Salam, and M. A. Vesterinen, Report on the Physics at the HL-LHC, and Perspectives for the HE-LHC.*, <https://cds.cern.ch/record/2703572>
 13. ATLAS Collaboration, *Search for bottom-squark pair production with the ATLAS detector in final states containing Higgs bosons, b -jets and missing transverse momentum*, JHEP 12 (2019) 060, arXiv:1908.03122 [hep-ex]
 14. ATLAS Collaboration, *Search for electroweak production of supersymmetric particles in final states with two or three leptons at $\sqrt{s} = 13$ TeV with the ATLAS detector*, Eur. Phys. J. C 78 (2018) 995, arXiv:1803.02762 [hep-ex]
 15. ATLAS Collaboration, *Search for direct top squark pair production in final states with two leptons in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS detector*, Eur. Phys. J. C 77 (2017) 898, arXiv:1708.03247 [hep-ex]

Conference notes:

1. ATLAS Collaboration, *Search for direct chargino pair production with W -boson mediated decays in events with two leptons and missing transverse momentum at $\sqrt{s} = 13$ TeV with the ATLAS detector.*, <https://cds.cern.ch/record/2632578> , ATLAS-CONF-2018-042
2. ATLAS Collaboration, *Search for direct top squark pair production and dark matter production in final states with two leptons in $\sqrt{s} = 13$ TeV pp collisions using 13.3 fb^{-1} of ATLAS data.*,

ATLAS briefing:

ATLAS Collaboration, *ATLAS sets strong constraints on supersymmetric dark matter*,. <https://atlas.cern/updates/briefing/strong-constraints-supersymmetric-dark-matter>

Conference talks and posters

Talks at international conferences:

- 2023 *ATLAS ITk Pixel Outer Endcap CO₂ cooling system prototype*, Forum on Tracking Detector Mechanics 2023, Tübingen, Germany
- 2022 *Electroweak SUSY at ATLAS and CMS*, MoriondQCD 2022 Conference, La Thuile, Italy
- 2021 Special overview talk, *ATLAS DESY group activity* on behalf of the ATLAS DESY group, DESY 91st Physics Research Committee meeting, Hamburg, Germany
- 2019 *Searches for sleptons with the ATLAS detector*, SUSY 2019 Conference, Corpus Christi, Texas
- 2018 *Search for electroweak production of supersymmetric gauginos and sleptons with the ATLAS detector*, Pheno 2018 Conference, Pittsburgh, Pennsylvania

Talks at national conferences:

- 2018 *Search for electroweak production of supersymmetric particles at LHC Run 2 with the ATLAS detector*, 17th IFAE Conference, Milano
- 2017 *Search for electroweak production of supersymmetric particles in multileptons final states at LHC Run 2 with the ATLAS detector*, 103rd National Conference of Società Italiana di Fisica, Trento
- 2016 *Search for Supersymmetric top partner with two leptons in the final state at the LHC Run 2 with the ATLAS detector*, 102nd National Conference of Società Italiana di Fisica, Padova

Poster at international conferences:

- 2017 *Search for electroweak production of Supersymmetric particles at LHC Run 2 with the ATLAS detector*, EPS Conference on High Energy Physics, Venice

Posters at national conferences:

- 2023 *CO₂ cooling system for the ITk Pixel detector for the ATLAS experiment*, 19th IFAE Conference, Catania

- 2017 S. Carrà, T. Lari, *Search for electroweak production of Supersymmetric particles at LHC Run 2 with the ATLAS detector*, Conference of the Department of Physics, University of Milano
- 2017 *Search for Supersymmetric scalar leptons at the LHC Run 2 with the ATLAS detector*, 16th IFAE Conference, Trieste
- 2016 *Search for top squark with two leptons in the final state at the LHC Run 2 with the ATLAS detector*, 15th IFAE Conference, Genova

Conference proceedings

1. ATLAS Collaboration, *Search for electroweak production of supersymmetric particles at LHC Run 2 with the ATLAS detector*, PoS EPS-HEP2017 (2018) 686
2. ATLAS Collaboration, *Search for top squark with two leptons in the final state at LHC Run 2 with the ATLAS detector*, Nuovo Cim. C40 (2017) 26

Awards and scholarships

- 2020 DESY scholarship for deserving research fellow
- 2018 INFN scholarship for Cooperation Associate position at CERN
- 2015 Postgraduate scholarship at University of Pavia, Department of Physics
- 2009 Scholarship for scientific degrees, University of Pavia

Outreach activity

- 2022 Organization of private visits at CERN.
- 2018 Didactic talk about *Data analysis and search for new physics* for bachelor students from the University of Pavia visiting CERN.
- 2016 - 2017 Guide at the EXTREME particle physics exhibition, at *Museo Nazionale della Scienza e della Tecnologia L. da Vinci* (Milano), during the European Researchers' Night.
- 2016 Assistant for a particle physics didactic laboratory at *Museo Nazionale della Scienza e della Tecnologia L. da Vinci* (Milano).
- 2015 Co-organizer of the kids didactic activity and assistant for European Researchers' Night, Pavia.
- 2015 - 2017 Laboratory assistant during the ATLAS International Masterclass, at University of Milano, Department of Physics.