Dr. Matthias **Raphael Stock**

Guest researcher, TUM

Technical University of Munich
TUM School of Natural Sciences
Physics Department (E15)
James-Franck-Str. 1, 85748 Garching, Germany

Email: raphael.stock@tum.de

Mobile: +49 (0)157 727 10068

Research Interests

Organic and water-based liquid scintillator development and characterization, instrumentation, neutrino physics, solar neutrinos, neutrino astronomy, active galactic nuclei

Education

05/2019 – 07/2025 **Dr. rer. nat. (PhD equivalent) in Physics**
Technische Universität München (TUM), Germany
Thesis: *"Development and Characterization of Novel Liquid Scintillators for the Detection of Neutrinos in Future Large-Scale Detectors,"*
Research Advisor: Prof. Dr. Lothar Oberauer
Doctoral defense took place on July 22, 2025.

10/2015 – 05/2018 **Master of Science in Physics**
Technische Universität München (TUM), Germany
Specialization in Nuclear, Particle and Astrophysics,
Thesis: *"Spectro-Interferometric Signatures of the Broad Line Regions in Active Galactic Nuclei,"* Research Advisor: Prof. Dr. Jason Dexter
Grade: 1.5 (passed with distinction)

09/2016 – 02/2017 **ERASMUS+ exchange student**
Sorbonne Université, France
Nuclei, Particles, Astroparticles and Cosmology (NPAC, Master 2 level)

10/2012 – 09/2015 **Bachelor of Science in Physics**
Technische Universität München (TUM), Germany
Grade: 2.6 (passed)

09/2004 – 06/2012 **Abitur** (General Higher Education Entrance Qualification)
Gymnasium Vilshofen, Germany
Grade: 2.5 (passed with merit)

Employment

11/2018 – 03/2025 **Research and teaching assistant**
Technical University of Munich,
TUM School of Natural Sciences, Physics Department,
Chair for Experimental Physics and Astroparticle Physics (E15), Germany

06/2018 – 09/2018 **Research assistant**
Max Planck Institute for Extraterrestrial Physics (MPE),
Infrared/Submillimeter Group, Germany

Professional Activities

05/2019 – 07/2025	**PhD Thesis** I study organic and water-based liquid scintillators comprising different solvents and fluors. Using UV light, radioactive sources and particle accelerators I characterize liquid scintillators, e.g., for JUNO and THEIA, concering emission spectra, UV, electron and proton scintillation time profiles, and proton quenching factors with dedicated experiments at room and cold temperatures. I thoroughly analyze the large amounts of data and compare them to models, which include numerical convolutions. Additionally, I characterized the used photomultiplier tubes (PMTs) concerning gain voltage dependency at single photoelectron (SPE) intensity using a picosecond laser system.
07/2022 – 03/2025	Laser protection officer of the chair E15, TUM
09/2020 – 03/2025	Chemistry laboratory manager of the chair E15, TUM
21/11/2024 – 01/12/2024	Active participation in a beamtime at the Heidelberger Ionenstrahl-Therapiezentrum, Heidelberg, Germany
04/2022 – 02/2023	JUNO Deputy Young Researcher Representative
07/03/2022 – 07/14/2022	Active participation in pumping out the far detector of the Double Chooz experiment, Centrale nucléaire de Chooz, France
04/22/2022 – 05/12/2022	Co-leading beamtimes at the CN accelerator and at the Tandem-XTU accelerator, INFN LNL, Legnaro, Italy
12/14/2021 – 12/24/2021	Co-leading a beamtime at the CN accelerator, INFN LNL, Legnaro, Italy
06/02/2021 – 06/22/2021	Co-leading a beamtime at the CN accelerator, INFN LNL, Legnaro, Italy
04/12/2021 – 04/23/2021	Active participation in pumping out the near detector of the Double Chooz experiment, Centrale nucléaire de Chooz, France
01/18/2021 – 01/30/2021	Active participation in pumping out the near detector of the Double Chooz experiment, Centrale nucléaire de Chooz, France
10/09/2019 – 10/11/2019	Co-organizer of the *"JUNO DFG Meeting 2019,"* TUM, Germany
09/16/2019 – 09/27/2019	Co-leading a beamtime at the MLL accelerator, Garching, Germany
07/27/2019 – 08/29/2019	Expert shifter at the *"PMT Characterization and Instrumentation Station for JUNO,"* Pan-Asia, Zhongshan, China
04/28/2019 – 05/06/2019	Co-leading a beamtime at the MLL accelerator, Garching, Germany
08/12/2018 – 08/16/2018	Assistence in an observing program with ESO VLTI GRAVITY/AT, 24 hours in total, Paranal Observatory, Chile
05/2017 – 05/2018	**Master's Thesis** I developed models of the broad line region (BLR) as a collection of optically thin clouds orbiting the supermassive black hole in an active galactic nucleus (AGN). Comparing model predictions for spectral lines and differential phases with interferometric VLTI/GRAVITY data of quasars, e.g., 3C 273, or other AGN, provide constraints on their orientation, structure and dynamics, such as black hole masses, BLR sizes or inclinations. Markov chain Monte Carlo (MCMC) methods were used.

Professional Affiliations

01/2021 – present	Double Chooz collaboration (international collaboration)
11/2019 – present	THEIA collaboration (international collaboration)
01/2019 – present	JUNO collaboration (international collaboration)
11/2017 – present	German Physical Society (DPG)

Teaching Experience and Training

Technische Universität München

Winter 2024/2025	Tutor, Introduction to Nuclear, Particle and Astrophysics (temporary assistance)
Summer 2024	Tutor, Physics II for Geodesy and Geo-Information (temporary assistance)
Summer 2022	Tutor, Particle Oscillations (offline and online)
Summer 2021	Tutor, Particle Oscillations (online)
Winter 2020/2021	Tutor, Introduction to Nuclear, Particle and Astrophysics (online)
Summer 2020	Tutor, Particle Oscillations (online)
Winter 2019/2020	Tutor, Introduction to Nuclear, Particle and Astrophysics
	Instructor, Physics Lab Course for Food Chemistry
	Tutor, Pre-study Physics course
Summer 2019	Tutor, Particle Oscillations

Co-supervision of Students

2 Master and 4 Bachelor students, Technische Universität München

Languages

- German (native)
- English (advanced, TOEFL iBT: 104/120, test made 2018)
- French (elementary, A2)
- Latin (Latinum)

Computer Skills

- LaTeX, Office programmes
- Python, Mathematica, MATLAB, OriginPro, ROOT
- Photoshop, GIMP, RAW converters, Inkscape

Summer Schools

- July 17 – 21, 2022 - Summer School of the SFB1258 Munich School on Neutrinos and Dark Matter (MONA), Raitenhaslach, Germany
- June 20 – 24, 2022 - SOUP2022 – The 2nd INFN School on Underground Physics, Gran Sasso National Laboratory and Gran Sasso Science Institute, Italy
- July 12 – 19, 2019 - 19th JINR-ISU Baikal Summer School on Physics of Elementary Particles and Astrophysics, Bolshiye Koty, Russia
- July 9 – 14, 2018 - 9th VLTI Summer School 2018, Lisbon, Portugal (with travel grant)

Invited Conference Presentations, Colloquia and Seminars

- December 7, 2023 - Plenary talk: *"Status and Prospects of the JUNO Experiment,"* **The 17th International Workshop on Tau Lepton Physics (TAU 2023)**, Louisville, Kentucky, USA
- February 23, 2023 - *"Liquid Scintillator Characterization Experiments for Particle Identification in JUNO and THEIA,"* **DESY**, Zeuthen, Germany (with travel grant)
- January 18, 2020 - *"Fluorescence Decay-Time Spectroscopy of the JUNO Liquid Scintillator using Gamma Radiation and a Pulsed Neutron Beam,"* **INFN Laboratori Nazionali di Legnaro**, Legnaro, Italy

Contributed Conference Presentations and Posters

- March 6, 2024 - *"Time Profile Measurements of the Cooled TAO Liquid Scintillator,"* **DPG Spring Meeting 2024**, Karlsruhe, Germany (with travel grant)
- August 30, 2023 - Poster: *Scintillation Time Profiles of Slow Organic and Water-Based Liquid Scintillators using a Pulsed Neutron Beam,"* **XVIII International Conference on Topics in Astroparticle and Underground Physics (TAUP 2023)**, Vienna, Austria
- March 23, 2023 - *"Fluorescence Time Profiles of Slow Organic and Water-Based Liquid Scintillators using a Pulsed Neutron Beam,"* **DPG Spring Meeting 2023**, Dresden, Germany (with travel grant)
- July 20, 2022 - Poster: *"Liquid Scintillator R&D: Overview of Quenching Factor and Scintillation Time Profile Measurements at INFN Legnaro,"* MONA Summer School, Raitenhaslach, Germany
- March 22, 2022 - *"Fluorescence Time Profiles of the JUNO and TAO Liquid Scintillators using a Pulsed Neutron Beam in the Energy Range from 3.5 to 5.5 MeV,"* **DPG Spring Meeting 2022**, Online
- March 16, 2021 - *"Measuring the Fluorescence Time Profile of the JUNO Scintillator with Gamma and Neutron Excitation,"* **DPG Spring Meeting 2021**, Online
- June 24, 2020 - Poster: *"Measuring the Fluorescence Time Profile of the JUNO Liquid Scintillator using Gamma Radiation and a Pulsed Neutron Beam,"* **The XXIX International Conference on Neutrino Physics and Astrophysics (Neutrino 2020)**, Online
- July 17, 2019 - *"Fluorescence Decay Time Measurements of JUNO LS using Gamma Radiation and a Pulsed Neutron Beam,"* **19th JINR-ISU Baikal Summer School on Physics of Elementary Particles and Astrophysics**, Bolshiye Koty, Russia

- December 10, 2018 - *"Spectro-Interferometric Signatures of the Broad Line Regions in Active Galactic Nuclei"*, **TORUS 2018**, Puerto Varas, Chile (with travel grant)
- July 10, 2018 - *"Spectro-Interferometric Signatures of the Broad Line Regions in Active Galactic Nuclei,"* **9th VLTI Summer School 2018**, Lisbon, Portugal (with travel grant)

Peer-Reviewed Publications

1860+ citations & h-index 20 (Google Scholar), ORCID: 0000-0002-5963-7431, INSPIRE, ADS, ResearchGate

31. *"PALM - Precision Attenuation Length Measurement in liquid scintillators,"* V. Rompel et al., including **M.R. Stock**, 2025, JINST **20** P04019

30. *"Potential to identify the neutrino mass ordering with reactor antineutrinos in JUNO,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2025, Chinese Phys. C **49** 033104

29. *"Prediction of energy resolution in the JUNO experiment,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2025, Chinese Phys. C **49** 013003

28. *"JUNO sensitivity to invisible decay modes of neutrons,"*, JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2025, Eur. Phys. J. C **85**, 5

27. *"The design and technology development of the JUNO central detector,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2024, Eur. Phys. J. Plus **139**, 1128

26. *"Development of a bi-solvent liquid scintillator with slow light emission,"* H. Th. J. Steiger, **M.R. Stock** et al., 2024, JINST **19** P09015
Contribution: *Active participation in the beamtimes and performing the data analysis of the emission spectra and scintillaton time profiles*

25. *"Development, characterization and production of a novel water-based liquid scintillator based on the Surfactant TRITON X-100,"* H. Th. J. Steiger, M. Böhles, **M.R. Stock** et al., 2024, JINST **19** P09008
Contribution: *Active participation in the beamtimes and performing the data analysis of the emission spectra and the scintillaton time profiles*

24. *"Model-independent Approach of the JUNO* ^{8}B *Solar Neutrino Program,"* JUNO Collaboration: J. Zhao et al., including **M.R. Stock**, 2024, ApJ **965** 122

23. *"Fast neutron production at the LNL Tandem from the* ^{7}Li(^{14}N, xn)X *reaction,"* P. Torres-Sánchez, H. Th. J. Steiger et al., including **M.R. Stock**, 2024, Eur. Phys. J. C **84**, 372,
Contribution: *Active participation in the beamtime*

22. *"Real-time monitoring for the next core-collapse supernova in JUNO,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2024, JCAP 01 (2024) 057, arXiv.2309.07109

21. *"JUNO sensitivity to* ^{7}Be*, pep, and CNO solar neutrinos,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2023, JCAP 10 (2023) 022, arXiv:2303.03910

20. *"The JUNO experiment Top Tracker,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2023, Nucl. Instr. and Meth. in Phys. Res. Sec. A 1057, 168680, arXiv:2303.05172

19. *"JUNO sensitivity to the annihilation of MeV dark matter in the galactic halo,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2023, JCAP 09 (2023) 001, arXiv.2306.09567

18. *"Nuclear physics midterm plan at Legnaro National Laboratories (LNL),"* M. Ballan et al., including **M.R. Stock**, 2023, Eur. Phys. J. Plus **138**, 709

17. *"JUNO sensitivity on proton decay $p \to \bar{\nu}K^+$ searches,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2023, Chinese Phys. C **47** (10), 1-17

16. *"Mass testing and characterization of 20-inch PMTs for JUNO,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2022, Eur. Phys. J. C **82**, 1168

15. *"Sub-percent precision measurement of neutrino oscillation parameters with JUNO,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2022, Chinese Phys. C **46** 123001

14. *"Prospects for detecting the diffuse supernova neutrino background with JUNO,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2022, JCAP 10 (2022) 033, arXiv:2205.08830v1

13. *"The Double Chooz antineutrino detectors,"* Double Chooz Collaboration: H. de Kerret et al., including **M.R. Stock**, 2022, Eur. Phys. J. C **82**, 804
Contribution: *Active participation onsite for measuring the mass of the liquid of the Gamma Catcher of the near detector to derive the proton number.*

12. *"Potential for a precision measurement of solar pp neutrinos in the Serappis Experiment,"* L. Bieger et al., including **M.R. Stock**, 2022, Eur. Phys. J. C **82**, 779

11. *"Damping signatures at JUNO, a medium-baseline reactor neutrino oscillation experiment,"* JUNO Collaboration: J. Wang et al., including **M.R. Stock**, 2022, J. High Energ. Phys. **2022**, 62

10. *"Combined sensitivity of JUNO and KM3NeT/ORCA to the neutrino mass ordering,"* KM3NeT Collaboration and JUNO Collaboration Members: S. Aiello et al. including **M.R. Stock**, 2022, J. High Energ. Phys. **2022**, 55

9. *"JUNO physics and detector,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2022, Progress in Particle and Nuclear Physics, 123, 103927, arXiv:2104.02565v2

8. *"Radioactivity control strategy for the JUNO detector,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2021, J. High Energ. Phys. **2021**, 102

7. *"The design and sensitivity of JUNO's scintillator radiopurity pre-detector OSIRIS,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2021, Eur. Phys. J. C **81**, 973

6. *"JUNO sensitivity to low energy atmospheric neutrino spectra,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2021, Eur. Phys. J. C **81**, 887

5. *"Calibration strategy of the JUNO experiment,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2021, J. High Energ. Phys. **2021**, 4

4. *"Feasibility and physics potential of detecting ^{8}B solar neutrinos at JUNO,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2021, Chinese Phys. C **45** 023004

3. *"THEIA: an advanced optical neutrino detector,"* M. Askins et al., including **M.R. Stock**, 2020, Eur. Phys. J. C **80**, 416

2. *"Combined sensitivity to the neutrino mass ordering with JUNO, the IceCube Upgrade, and PINGU,"* IceCube-Gen2 Collaboration, and JUNO Collaboration Members: M. G. Aartsen et al., including **M.R. Stock**, 2020, Phys. Rev. D **101**, 032006

1. *"Spatially resolved rotation of the broad-line region of a quasar at sub-parsec scale,"* GRAVITY collaboration: E. Sturm, J. Dexter, O. Pfuhl, **M.R. Stock** et al., 2018, Nature **563**, 657–660, arXiv:1811.11195v1
   Contribution: *Developed models and fit them to VLTI/GRAVTIY data of the quasar 3C 273 to derive, e.g., broad-line region size and black hole mass.*

Peer-Reviewed Conference Proceedings

- *"Status and Prospects of the JUNO Experiment,"* **M.R. Stock**, on behalf of the JUNO Collaboration, 2025, SciPost Phys. Proc. 17, 020, arXiv:2405.07321
  Corresponding author

- *"Scintillation Time Profiles of Slow Organic and Water-Based Liquid Scintillators using a Pulsed Neutron Beam,"* **M.R. Stock** et al., 2024, PoS (TAUP2023) 287
  Corresponding author

Selected Unrefereed Publications

- *"Simulation of the Background from $^{13}C(\alpha, n)^{16}O$ Reaction in the JUNO Scintillator,"* JUNO Collaboration: T. Adam et al., including **M.R. Stock**, 2025, accepted by Eur. Phys. J. C arXiv:2503.00968

- *"The Core of the Matter — Spatially Resolving Active Galactic Nuclei with GRAVITY,"* GRAVITY collaboration: E. Sturm et al., including **M.R. Stock**, 2022, ESO The Messenger, 188:20-25

- *"THEIA: Summary of physics program. Snowmass White Paper Submission,"* M. Askins et al., including **M.R. Stock**, 2022, arXiv:2202.12839v1

- *"TAO Conceptual Design Report: A Precision Measurement of the Reactor Antineutrino Spectrum with Sub-percent Energy Resolution,"* JUNO Collaboration: A. Abusleme et al., including **M.R. Stock**, 2020, arXiv:2005.08745v1

- *"Spatially Resolving the Quasar Broad Emission Line Region,"* GRAVITY collaboration: R. Abuter et al., including **M.R. Stock**, 2019, ESO The Messenger, 178:20–24