

Curriculum Vitæ: John W. Belz

Current Address

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Education

Postdoctoral Rutgers University (G. Thomson and S. Somalwar)
Ph.D. (Physics) Temple University (1993) (K. McFarlane)
B.A. (Physics) Temple University (1987)

Professional Positions

2020– Professor, University of Utah
2014–2020 Associate Professor, University of Utah
2009–2013 Research Associate Professor, University of Utah
2006–2009 Research Assistant Professor, University of Utah
2005–2006 Visiting Assistant Professor, University of Utah
2002–2006 Assistant Professor, University of Montana
1999–2002 Research Assistant Professor, Montana State University
1992–1999 Postdoctoral Research Associate, Rutgers University
1987–1992 Graduate Research Assistant, Temple University

Research Activities

2018– Numerical Relativity
2013– TA/LMA: Lightning Research with Telescope Array
2008–2017 TARA: Radar Detection of Cosmic Ray Airshowers
2005– Telescope Array: Study of High Energy Cosmic Rays
2002–2008 SLAC E-165 (FLASH): Nitrogen Fluorescence in Air Showers
1998–2010 The High-Resolution Fly's Eye: Study of Highest Energy Cosmic Rays
1992–2003 FNAL E832/E799 (KTeV): CP Violation in Neutral Kaons
1986–1998 BNL E791: Search for Rare Kaon Decays

Recent Research Collaborators

R. Abbasi (Loyola), D. Bergman, B. Farhang-Boroujeny, C. Jui, J. Matthews, P. Sokol-sky, G. Thomson (Utah), D. Neilsen, E. Hirschmann (Brigham Young University) H. Takai (Brookhaven), D. Besson (Kansas), P. Krehbiel, W. Rison, R. Thomas, M. Stanley (NM Tech), C. Sinnis (Los Alamos), M. Fukushima, T. Nonaka, H. Sagawa (ICRR, Tokyo) S. Ogio, Y. Tsunesada (Osaka), B. Knapp, S. Westerhoff (Columbia), P. Chen, C. Field, A. Odian, D. Walz (SLAC).

Research Funding

- PENDING “Numerical Simulation of Black Holes and Gravitational Waves”, NSF proposal PHY-2208083, submitted November 2021, \$98,681. *Principal Investigator.*
- CURRENT “The Microphysics of Lightning: Observing the Optical Emission from Downward Terrestrial Gamma-ray Flashes”, NSF/AGS-2112709, \$505,230 2021-2024. *Co-Investigator.*
- CURRENT “Investigation of Downward Gamma Ray Showers from Natural Lightning”, NSF #AGS-1844306, \$733,382 (2019-2022). *Principal Investigator.*
- CURRENT “Baseline Support of the University of Utah Cosmic Ray Physics Group Including Analysis of Telescope Array, TALE, and TA \times 4 Data”, NSF/PHY-1806797, \$2,172,872 (2018-2021). *Senior Personnel.*
- CURRENT “Operation of the Telescope Array, TALE, and the TA \times 4 Expansion”, NSF #PHY-1712517 \$800,000 (2017-2020). *Senior Personnel.*
- “Investigating the Correlation Between Lightning and High-Energy Particles in the Earth’s Atmosphere”, NSF #AGS-1613260, \$471,167 (2016-2019). *Principal Investigator.*
- “TA \times 4: Expanding the Aperture of the Telescope Array by a Factor of Four”, NSF #PHY-1607727 \$1,775,000 (2016–2019). *Senior Personnel.*
- “Baseline Support for the University of Utah Cosmic Ray Physics Group, Including Telescope Array”, NSF #PHY-1404495, \$1,853,364 (2014–2017). *Senior Personnel.*
- “Telescope Array Operations and Data Analysis”, NSF #PHY-1404502, \$2,290,797 (2014–2017). *Senior Personnel.*
- “A Radar Observatory for the Universe’s Most Energetic Particles”, W. M. Keck Foundation, \$1,000,000 (2012–2017). *Principal Investigator.*
- “MRI: Development of a Radar Observatory for Cosmic Ray Air Showers”, NSF #MRI-1126353, \$571,000 (2011–2015). *Principal Investigator.*
- “Baseline Support for the University of Utah Cosmic Ray Physics Group, Including Telescope Array”, NSF #PHY-1069280, \$3,124,772 (2010–2013). *Senior Personnel.*
- “Telescope Array Operations and Data Analysis”, NSF #PHY-1069286, \$1,707,240 (2010–2013). *Senior Personnel.*
- “Detection of Cosmic Ray Airshowers by Bistatic Radar”, NSF #PHY-0969865 Supplement, \$52,000 (2010–2013). *Principal Investigator.*
- “Data Acquisition and Test Equipment for Bistatic Radar Cosmic Ray Observatory”, Albaugh Scientific Instrumentation Award, \$20,000 (2011). *Principal Investigator.*
- “Detection of Cosmic Ray Airshowers by Bistatic Radar”, NSF #PHY-0969865, \$267,256 (2010–2013). *Principal Investigator.*

- “Detection of Cosmic Ray Airshowers by Bistatic Radar”, University of Utah Funding Incentive Seed Grant, \$34,689 (2009–2010). *Principal Investigator*.
- “Baseline Support for the University of Utah Cosmic Ray Physics Group, Including Telescope Array”, NSF #PHY-0848320, \$2,271,046 (2008–2011). *Senior Personnel*.
- “FLASH - FLuorescence in Air SHowers”, NSF #PHY-0400053 \$120,000 (2005–2006) *Co-Investigator*.
- “Study of the Highest–Energy Cosmic Rays”, NSF #PHY-0245428, \$160,000 (2003–2007). *Principal Investigator*.
- “Aerospace Workforce Development”, Montana Space Grant Consortium \$14,300 (2003–2004). *Principal Investigator*.
- “Measurement of Tropospheric and Stratospheric Ozone Concentrations in South–Central Montana”, M.J. Murdock Trust, \$14,000 (2002–2004). *Principal Investigator*.
- “Study of the Highest–Energy Cosmic Rays”, NSF #PHY-0071069, \$120,000 (2000–2003). *Principal Investigator*.
- “A Cosmic-Ray Spark Chamber for Astronomy Education and Public Display”, Montana Space Grant Consortium, \$34,795 (2001–2003). *Principal Investigator*.
- “Upgrading the MSU Physics Undergraduate Electronics Laboratory”, Montana State University Equipment Fund \$26,024 (2001–2002). *Principal Investigator*.

Research Mentoring (current in bold)

Undergraduate Students: R. Belohlavek, J. Kaun, S. Kirn, M. Munro (Montana State), E. Fitzhenry, A. Goldammer, D. Guest, K. Moniz (U. Montana), M. Byrne, C. Holdaway, **C. Kelson-Packer**, R. LeVon, J. Lundquist, W. Phillips, J. Rankin, **A. Petrizze**, I. Reznik, **K. Smout**, J. Thomas, B. Van Klaveren (Utah).

Graduate Students: M. Kirn (Masters, Montana State), M. Dalton (Masters, Utah), I. Myers (Doctoral, Utah). J. Remington (Doctoral, Utah), R. LeVon (Masters, Utah), **S. Johnson** (Doctoral, Utah).

Postdoctoral Scholars: R. Abbasi, E. Barcikowski, W. Hanlon, I. Myers (Utah).

Synergistic Activities

- Science blogger, *Disciples of Flight* aviation website.
- Paper review, *Astroparticle Physics*.
- Proposal review, National Science Foundation.
- Outreach: HiRes/TA ASPIRE program (1999–present).
- Outreach: BOREALIS near-space exploration platform (2001-2005).
<http://spacegrant.montana.edu/borealis/>
- Montana NASA EPSCOR Technical Advisory Committee (2002-2005).
- Proposal review, Montana Space Grant Consortium (MSGC) (2002-2005).

Department and University Service

- University Endorsed Scholarship Endorsement Committee (2021-present)
- Physics Graduate Recruitment and Admissions (2021-present)
- College Council (2019-2021)
- College of Science Curriculum and Articulation Committee (2019-2020).
- Physics and Astronomy Policy Board (2019-2020).
- Developing *Computational Physics* Emphasis (2019-2021).
- Developer *Physics 2235, Computational Laboratory for Physicists* (2016-present)
- High Energy Astrophysics (HEAP) Seminar (2017-present).
- Chair, Physics & Astronomy Undergraduate Development Committee (2015-2017).
- Member, Physics & Astronomy Policy Board (2015-2016).
- Director of Undergraduate Studies, Physics and Astronomy (2014-present).
- Committee member, Physics & Astronomy Academic Advisor Search (2013-2014).
- Various Department Retention, Promotion, Tenure (RPT) committees, (2012-present).
- Curriculum Committee (2010-2011)
- Chair, Capital Facilities and Remodeling Committee (2009-2010)
- Common Exam Preparation Committee (2009-2010)

Courses Taught

Course	Semester(s)	Text
Computing in Physics II (Φ 5730, UU [†])	S22	
General Relativity (Φ 7720, UU)	F21	Carroll
Classical Physics I (Φ 4410, UU)	F18	Thornton
Physics for Scientists I (Φ 3210, UU)	F16, S17, 18, 19	Kleppner
Physics for Scientists II (Φ 3220, UU)	F15	Purcell
Physics for Scientists and Engineers I (Φ 2210, UU)	F13, F14	smartPhysics
Graduate Laboratory (Φ 6719, UU)	S08, 9, 10, 12	Taylor
Undergraduate Laboratory (Φ 3719, UU)	F07, 8, 9, 10, S11	Taylor
Introduction to Computing in Physics (Φ 3730/6720, UU)	F06, 11, S16, F19	
Introduction to Nuclear and Particle Physics (Φ 5110, UU)	S06, 13, 14, 15, 20	Martin
Elementary Physics (Φ 1010, UU)	F05, S07	Griffith
Fundamentals of Physics II (Φ 122, UM)	S05 (\times 2)	Giancoli
Elementary Astronomy Laboratory (Φ 134, UM)	F04	
Fundamentals of Physics I (Φ 121, UM)	F04	Giancoli
Modern Experimental Physics Laboratory (Φ 441, UM)	S03, 04	Horowitz
Electromagnetism I (Φ 414, UM)	F03	Griffiths
Fundamentals of Modern Physics (Φ 341, UM)	F02, 03	Krane
Phys. Measurements II: Digital Electronics (Φ 361, MSU)	F01	Barnaal
Demystifying Quantum Mechanics (Φ 530, MSU)	F00	Feynman
Phys. Measurements I: Analog Electronics (Φ 261, MSU)	F00, 01	Barnaal
Mathematical Methods in Physics (Φ 231, MSU)	S00, 01, 02	Boas
Introduction to Astronomy (Φ 311, MSU)	F99	Morrison
Particle Physics for Teachers (Φ 580, MSU)	S99	Coughlan

[†] UU: University of Utah, UM: University of Montana, MSU: Montana State

Publications (Primary or Major Author)

- OBSERVATION OF VARIATIONS IN COSMIC RAY SINGLE COUNT RATES DURING THUNDERSTORMS AND IMPLICATIONS FOR LARGE-SCALE ELECTRIC FIELD CHANGES, R.U. Abbasi et al., accepted for publication in *Phys. Rev. D*, December 2021. e-Print: 2111.09962.
- BOUNDARY DYNAMICS IN COMPETING CRITICAL BLACK HOLE FORMATION, C. Kelson-Packer and J. Belz, submitted to *Phys. Rev. D*, August 2021. arXiv:2108.06355.
- OBSERVATION OF THE ORIGIN OF DOWNWARD TERRESTRIAL GAMMA-RAY FLASHES, J. Belz et al., *J. Geophys. Res.* **125** e2019JD031940 (2020). DOI:10.1029/2019JD031940. arXiv:2009.14327.
- INVESTIGATION INTO LENGTH SCALE DOMINANCE IN CRITICAL BLACK HOLE FORMATION, C. Kelson-Packer and J. Belz, *Phys. Rev. D* **102** 084050 (2020). arXiv:2008.06774.
- STUDY OF MUONS FROM ULTRA-HIGH ENERGY COSMIC RAY AIR SHOWERS MEASURED WITH THE TELESCOPE ARRAY EXPERIMENT, R.U. Abbasi et al., *Phys. Rev D* **98**, 022002 (2018).
- GAMMA-RAY SHOWERS OBSERVED AT GROUND LEVEL IN COINCIDENCE WITH DOWNWARD LIGHTNING LEADERS, R.U. Abbasi et al., *J. Geophys. Res.* **123** 6864-6879 (2018), DOI: 10.1029/2017JD027931.
- THE BURSTS OF HIGH ENERGY EVENTS OBSERVED BY THE TELESCOPE ARRAY SURFACE DETECTOR, R.U. Abbasi et al., *Physics Letters A* 381 pp. 2565-2572 (2017).
- PERFORMANCE ANALYSIS OF MATCHED FILTER BANK FOR DETECTION OF LINEAR CHIRP SIGNALS, M. Abou Bakr Othman, J. Belz, and B. Farhang-Boroujeny, *IEEE Transactions on Aerospace and Electronic Systems* **53** 1 (2017).
- FIRST UPPER LIMITS ON THE RADAR CROSS SECTION OF COSMIC-RAY INDUCED EXTENSIVE AIR SHOWERS, R.U. Abbasi et al., *Astroparticle Physics* **87** p1-17 (2017). DOI: 10.1016/j.astropartphys.2016.11.006.
- RADAR DETECTION OF HIGH-ENERGY COSMIC RAYS IN NON-GAUSSIAN BACKGROUND USING A TIME-FREQUENCY TECHNIQUE, M. Abou Bakr Othman, J. Belz, and B. Farhang-Boroujeny, *Digital Signal Processing* **56** 24 (2016).
- MEASUREMENT OF THE PROTON-AIR CROSS SECTION WITH TELESCOPE ARRAY'S MIDDLE DRUM DETECTOR AND SURFACE ARRAY IN HYBRID MODE, R.U. Abbasi et al., *Phys. Rev. D* **92** 032007 (2015).
- DESIGN, CONSTRUCTION AND OPERATION OF A LOW-POWER, AUTONOMOUS RADIO FREQUENCY DATA-ACQUISITION STATION FOR THE TARA EXPERIMENT, S. Kunwar et al., *Nucl. Inst. Meth A* **797** 110 (2015).

- STUDY OF ULTRA-HIGH ENERGY COSMIC RAY COMPOSITION USING TELESCOPE ARRAY'S MIDDLE DRUM DETECTOR AND SURFACE ARRAY IN HYBRID MODE, R.U. Abbasi et al. *Astropart.Phys.* **64** 49 (2014).
- TELESCOPE ARRAY RADAR (TARA) OBSERVATORY FOR ULTRA-HIGH ENERGY COSMIC RAYS, R. Abbasi et al., *Nucl. Inst. Meth.* **A 767** p. 322 (2014).
- INDICATIONS OF PROTON-DOMINATED COSMIC-RAY COMPOSITION ABOVE 1.6 EeV, by the HiRes Collaboration, R. Abbasi et al., *Phys. Rev. Lett.* **104** 161101 (2010).
- THE FLASH THICK-TARGET EXPERIMENT, by the FLASH Collaboration (R. Abbasi et al.), *Nucl. Inst. Meth.* **A 597** p. 37 (2008).
- AIR FLUORESCENCE MEASUREMENTS IN THE SPECTRAL RANGE 300-410 NM USING A 28.5 GEV ELECTRON BEAM, by the FLASH collaboration, R. Abbasi et al., *Astropart. Phys.* **29** 77 (2008).
- COSMIC RAYS: THE SECOND KNEE AND BEYOND, Douglas R Bergman, John W. Belz, *J.Phys.* G34:R359, (2007). e-Print: arXiv:0704.3721.
- SEARCH FOR POINT-LIKE SOURCES OF COSMIC RAYS WITH ENERGIES ABOVE $10^{18.5}$ EV IN THE HIRES-I MONOCULAR DATA-SET, by HiRes Collaboration (R.U. Abbasi et al.), *Astropart.Phys.* **27** 212 (2007). e-Print Archive: astro-ph/0507663.
- COMPARISON OF AIR FLUORESCENCE AND IONIZATION MEASUREMENTS OF E.M. SHOWER DEPTH PROFILES: TEST OF A UHECR DETECTOR TECHNIQUE, by the FLASH Collaboration (J. Belz et al.), *Astropart. Phys.* **25** 57 (2006). e-Print Archive: astro-ph/0510375.
- MEASUREMENT OF PRESSURE DEPENDENT FLUORESCENCE YIELD OF AIR: CALIBRATION FACTOR FOR UHECR DETECTORS, by the FLASH Collaboration (J.W. Belz et al.), *Astropart. Phys.* **25** 129 (2006). e-Print Archive: astro-ph/0506741.
- MEASUREMENTS OF DIRECT CP VIOLATION, CPT SYMMETRY, AND OTHER PARAMETERS IN THE NEUTRAL KAON SYSTEM, by KTeV Collaboration (A. Alavi-Harati et al.), Published in *Phys. Rev.* D67 012005, 2003, Erratum *ibid.* D70:079904, 2004, e-Print Archive: hep-ex/0208007.
- MEASUREMENTS OF THE RARE DECAY $K_L \rightarrow e^+e^-e^+e^-$, by KTeV Collaboration (A. Alavi-Harati et al.), Published in *Phys. Rev. Lett.* 86:5425-5429, 2001, e-Print Archive: hep-ex/0104043.
- STUDY OF THE $K_L^0 \rightarrow \pi^+\pi^-\gamma$ DIRECT EMISSION VERTEX, by The KTeV Collaboration (A. Alavi-Harati et al.), Published in *Phys. Rev. Lett.* 86:761-764, 2001, e-Print Archive: hep-ex/0008045.

- OBSERVATION OF DIRECT CP VIOLATION IN $K_{S,L} \rightarrow \pi\pi$ DECAYS, by KTeV Collaboration (A. Alavi-Harati et al.), Published in Phys. Rev. Lett. 83:22,1999, e-Print Archive: hep-ex/9905060.
- A COMPACT BEAM STOP FOR A RARE KAON DECAY EXPERIMENT, by E871 Collaboration (J. Belz et al.), Published in Nucl.Instrum.Meth.A428:239-262,1999, e-Print Archive: hep-ex/9808037.
- A CHERENKOV COUNTER DESIGNED AS A MUON TRIGGER FOR THE SDC DETECTOR, M. Albee et al.. 1993, Published in Nucl.Instrum.Meth.A325:429-440,1993.
- IMPROVED SENSITIVITY IN A SEARCH FOR THE RARE DECAY $K_L^0 \rightarrow e^+e^-$, by BNL E791 Collaboration (K. Arisaka et al.), Published in Phys. Rev. Lett. 71:3910-3913,1993.

Complete List of Publications

- SEARCH FOR SPATIAL CORRELATIONS OF NEUTRINOS WITH ULTRA-HIGH-ENERGY COSMIC RAYS, A. Albert et al., submitted to *Ap. J.*, January 2022. e-Print: 2201.07313.
- OBSERVATION OF VARIATIONS IN COSMIC RAY SINGLE COUNT RATES DURING THUNDERSTORMS AND IMPLICATIONS FOR LARGE-SCALE ELECTRIC FIELD CHANGES, R.U. Abbasi et al., accepted for publication in *Phys. Rev. D*, December 2021. e-Print: 2111.09962.
- INDICATIONS OF A COSMIC RAY SOURCE IN THE PERSEUS-PISCES SUPERCLUSTER, R.U. Abbasi et al., submitted to *Astrophysical Journal* (2021). e-Print: 2110.14827
- BOUNDARY DYNAMICS IN COMPETING CRITICAL BLACK HOLE FORMATION, C. Kelson-Packer and J. Belz, submitted to *Phys. Rev. D*, August 2021. arXiv:2108.06355.
- SURFACE DETECTORS OF THE TA \times 4 EXPERIMENT, R.U. Abbasi et al, *Nucl. Instrum. Meth. A* 1019 (2021).
- THE COSMIC-RAY COMPOSITION BETWEEN 2 PeV AND 2 EeV OBSERVED WITH THE TALE DETECTOR IN MONOCULAR MODE, R.U. Abbasi et al., *Astrophysical Journal* **909** 178 (2021). arXiv:2012.10372.
- OBSERVATION OF THE ORIGIN OF DOWNWARD TERRESTRIAL GAMMA-RAY FLASHES, J. Belz et al., *J. Geophys. Res.* **125** e2019JD031940 (2020). DOI:10.1029/2019JD031940. arXiv:2009.14327.
- INVESTIGATION INTO LENGTH SCALE DOMINANCE IN CRITICAL BLACK HOLE FORMATION, C. Kelson-Packer and J. Belz, *Phys. Rev. D* **102** 084050 (2020). arXiv:2008.06774.
- EVIDENCE FOR A SUPERGALACTIC STRUCTURE OF MAGNETIC DEFLECTION MULTIPLETS OF ULTRA-HIGH ENERGY COSMIC RAYS, R.U. Abbasi et al., *Ap. J.* **899** 86 (2020). e-Print: 2005.07312.
- MEASUREMENT OF THE PROTON-AIR CROSS SECTION WITH TELESCOPE ARRAY'S BLACK ROCK MESA AND LONG RIDGE FLUORESCENCE DETECTORS, AND SURFACE ARRAY IN HYBRID MODE, R.U. Abbasi et al., *Phys. Rev. D* **102** 062005 (2020). e-Print: 2006.05012.
- SEARCH FOR POINT SOURCES OF ULTRA-HIGH ENERGY PHOTONS WITH THE TELESCOPE ARRAY SURFACE DETECTOR, R.U. Abbasi et al., *Mon. Not. Roy. Astron. Soc.* **492** 3984-3993 (2020).
- SEARCH FOR ULTRA-HIGH ENERGY NEUTRINOS WITH THE TELESCOPE ARRAY SURFACE DETECTOR, R.U. Abbasi et al., *J. Exp. Theor. Phys.* **131** 255-264 (2020). e-Print: 1905.03738.

- SEARCH FOR A LARGE-SCALE ANISOTROPY ON ARRIVAL DIRECTIONS OF ULTRAHIGH-ENERGY COSMIC RAYS OBSERVED WITH THE TELESCOPE ARRAY EXPERIMENT, R.U. Abbasi et al. *Astrophys. J.* **898** 2, L28 (2020). e-Print:2007.00023.
- CONSTRAINTS ON THE DIFFUSE PHOTON FLUX WITH ENERGIES ABOVE 10^{18} eV USING THE SURFACE DETECTOR OF THE TELESCOPE ARRAY EXPERIMENT, R.U. Abbasi et al., *Astropart. Phys.* **110** (2019). arXiv:1811.03920.
- MASS COMPOSITION OF ULTRA-HIGH-ENERGY COSMIC RAYS WITH THE TELESCOPE ARRAY SURFACE DETECTOR DATA, R.U. Abbasi et al., *Phys. Rev. D* **99** (2019). arXiv:1808.03680.
- TESTING A REPORTED CORRELATION BETWEEN ARRIVAL DIRECTIONS OF ULTRAHIGH-ENERGY COSMIC RAYS AND A FLUX PATTERN FROM NEARBY STARBURST GALAXIES USING TELESCOPE ARRAY DATA, R.U. Abbasi et al., *Astrophys. J.* 867 no.2, L27 (2018).
- THE COSMIC-RAY ENERGY SPECTRUM BETWEEN 2 PEV AND 2 EEV OBSERVED WITH THE TALE DETECTOR IN MONOCULAR MODE, R.U. Abbasi et al., *Ap. J.* **865** 74 (2018).
- EVIDENCE OF INTERMEDIATE-SCALE ENERGY SPECTRUM ANISOTROPY OF COSMIC RAYS $E \geq 10^{19.2}$ EV WITH THE TELESCOPE ARRAY SURFACE DETECTOR, R.U. Abbasi et al., *Ap. J.* **862** 91 (2018).
- STUDY OF MUONS FROM ULTRA-HIGH ENERGY COSMIC RAY AIR SHOWERS MEASURED WITH THE TELESCOPE ARRAY EXPERIMENT, R.U. Abbasi et al., *Phys. Rev. D* **98**, 022002 (2018).
- GAMMA-RAY SHOWERS OBSERVED AT GROUND LEVEL IN COINCIDENCE WITH DOWNWARD LIGHTNING LEADERS, R.U. Abbasi et al., *J. Geophys. Res.* **123** 6864-6879 (2018), DOI: 10.1029/2017JD027931.
- EUSO-TA — FIRST RESULTS FROM A GROUND-BASED EUSO TELESCOPE, G. Abdellaoui et al., *Astropart. Phys.* **102**, 98-111 (2018).
- DEPTH OF ULTRA HIGH ENERGY COSMIC RAY INDUCED AIR SHOWER MAXIMA MEASURED BY THE TELESCOPE ARRAY BLACK ROCK AND LONG RIDGE FADC FLUORESCENCE DETECTORS AND SURFACE ARRAY IN HYBRID MODE, R.U. Abbasi et al., *Ap. J.* **858** p. 76 (2018).
- THE BURSTS OF HIGH ENERGY EVENTS OBSERVED BY THE TELESCOPE ARRAY SURFACE DETECTOR, R.U. Abbasi et al., *Physics Letters A* 381 pp. 2565-2572 (2017).
- SEARCH FOR EEV PROTONS OF GALACTIC ORIGIN, R.U. Abbasi et al., *Astroparticle Physics* **86** 21 (2017).

- PERFORMANCE ANALYSIS OF MATCHED FILTER BANK FOR DETECTION OF LINEAR CHIRP SIGNALS, M. Abou Bakr Othman, J. Belz, and B. Farhang-Boroujeny, *IEEE Transactions on Aerospace and Electronic Systems* **53** 1 (2017).
- FIRST UPPER LIMITS ON THE RADAR CROSS SECTION OF COSMIC-RAY INDUCED EXTENSIVE AIR SHOWERS, R.U. Abbasi et al., *Astroparticle Physics* **87** p1-17 (2017). DOI: 10.1016/j.astropartphys.2016.11.006.
- THE ENERGY SPECTRUM OF COSMIC RAYS ABOVE $10^{17.2}$ EV MEASURED BY THE FLUORESCENCE DETECTORS OF THE TELESCOPE ARRAY EXPERIMENT IN SEVEN YEARS, R.U. Abbasi et al., *Astropart.Phys.* **80** 131-140 (2016), arXiv:1511.07510.
- RADAR DETECTION OF HIGH-ENERGY COSMIC RAYS IN NON-GAUSSIAN BACKGROUND USING A TIME-FREQUENCY TECHNIQUE, M. Abou Bakr Othman, J. Belz, and B. Farhang-Boroujeny, *Digital Signal Processing* **56** 24 (2016).
- THE ENERGY SPECTRUM OF COSMIC RAYS ABOVE 10^{17} EV MEASURED BY THE FLUORESCENCE DETECTORS OF THE TELESCOPE ARRAY EXPERIMENT IN SEVEN YEARS, R.U. Abbasi et al., *Astroparticle Physics* **80** 131 (2016).
- MEASUREMENT OF THE PROTON-AIR CROSS SECTION WITH TELESCOPE ARRAY'S MIDDLE DRUM DETECTOR AND SURFACE ARRAY IN HYBRID MODE, R.U. Abbasi et al., *Phys. Rev. D* **92** 032007 (2015).
- DESIGN, CONSTRUCTION AND OPERATION OF A LOW-POWER, AUTONOMOUS RADIO FREQUENCY DATA-ACQUISITION STATION FOR THE TARA EXPERIMENT, S. Kunwar et al., *Nucl. Inst. Meth* **A797** 110 (2015).
- A NORTHERN SKY SURVEY FOR POINT-LIKE SOURCES OF EEV NEUTRAL PARTICLES WITH THE TELESCOPE ARRAY EXPERIMENT, by the Telescope Array Collaboration, R. U. Abbasi et al. 2015 *Ap. J.* **804** 133 (2015).
- THE HYBRID ENERGY SPECTRUM OF TELESCOPE ARRAY'S MIDDLE DRUM DETECTOR AND SURFACE ARRAY, by the Telescope Array Collaboration, R. Abbasi et al., *Astropart. Phys.* **68** 27 (2015).
- ENERGY SPECTRUM OF ULTRA-HIGH ENERGY COSMIC RAYS OBSERVED WITH THE TELESCOPE ARRAY USING A HYBRID TECHNIQUE, by the Telescope Array Collaboration, T. Abu-Zayyad et al., *Astropart.Phys.* **61** 93 (2015). e-Print: arXiv:1305.7273.
- STUDY OF ULTRA-HIGH ENERGY COSMIC RAY COMPOSITION USING TELESCOPE ARRAY'S MIDDLE DRUM DETECTOR AND SURFACE ARRAY IN HYBRID MODE, R.U. Abbasi et al. *Astropart.Phys.* **64** 49 (2014).
- GAIN MONITORING OF TELESCOPE ARRAY PHOTOMULTIPLIER CAMERAS FOR THE FIRST FOUR YEARS OF OPERATION, B. K. Shin et al., *Nucl. Inst. Meth A* **768** 96 (2014).

- SEARCHES FOR LARGE-SCALE ANISOTROPY IN THE ARRIVAL DIRECTIONS OF COSMIC RAYS DETECTED ABOVE ENERGY OF 10^{19} EV AT THE PIERRE AUGER OBSERVATORY AND THE TELESCOPE ARRAY, A. Aab et al., *Astrophys. J.* **794** 172 (2014).
- TELESCOPE ARRAY RADAR (TARA) OBSERVATORY FOR ULTRA-HIGH ENERGY COSMIC RAYS, R. Abbasi et al., *Nucl. Instr. Meth.* **A 767** p. 322 (2014).
- INDICATIONS OF INTERMEDIATE SCALE ANISOTROPY OF COSMIC RAYS WITH ENERGY GREATER THAN 57 EeV IN THE NORTHERN SKY MEASURED WITH THE SURFACE DETECTOR OF THE TELESCOPE ARRAY EXPERIMENT, by the Telescope Array Collaboration, R. Abbasi et al., *Ap. J.* **790** L21 (2014).
- CORRELATIONS OF THE ARRIVAL DIRECTIONS OF ULTRA-HIGH ENERGY COSMIC RAYS WITH EXTRAGALACTIC OBJECTS AS OBSERVED BY THE TELESCOPE ARRAY EXPERIMENT, by the Telescope Array Collaboration, T. Abu-Zayyad et al., *Astrophys.J.* **777** 88 (2013).
- THE ENERGY SPECTRUM OF ULTRA-HIGH ENERGY COSMIC RAYS MEASURED BY THE TELESCOPE ARRAY FADC FLUORESCENCE DETECTORS IN MONOCULAR MODE, by the Telescope Array Collaboration, T. Abu-Zayyad et al.), *Astropart. Phys.* **48** 16 (2013).
- UPPER LIMIT ON THE FLUX OF PHOTONS WITH ENERGIES ABOVE 10^{19} eV USING TELESCOPE ARRAY SURFACE DETECTOR, by the Telescope Array Collaboration, T. Abu-Zayyad et al.), *Phys. Rev.* **D88** 112005 (2013).
- THE COSMIC RAY ENERGY SPECTRUM OBSERVED WITH THE SURFACE DETECTOR OF THE TELESCOPE ARRAY EXPERIMENT, by the Telescope Array Collaboration, T. Abu-Zayyad et al., *Ap. J. Lett.* **768**:L1 (2013).
- SEARCH FOR ANISOTROPY OF ULTRA-HIGH ENERGY COSMIC RAYS WITH THE TELESCOPE ARRAY EXPERIMENT, by the Telescope Array Collaboration, T. Abu-Zayyad et al., *Ap.J.* **757** 26 (2012).
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Conferences and Colloquia

- “Observations and Simulations of the Origin of Downward Terrestrial Gamma-Ray Flashes”, American Geophysical Union Fall Meeting, New Orleans, Louisiana 12 December 2021.
- “Observing the Origins of Terrestrial Gamma-ray Flashes”, invited talk, Cosmic Ray International Symposium (CRIS2020), Vietri Sul Mare, Italy 7-11 September 2020. Conference cancelled due to pandemic.
- “Observations of Terrestrial Gamma Ray Flashes at the Telescope Array Cosmic Ray Detector”, invited talk, 36th International Cosmic Ray Conference, Madison, Wisconsin, 31 July 2019.
- “Observing the Origins of Terrestrial Gamma-ray Flashes”, University of Utah Physics and Astronomy Colloquium, Salt Lake City, Utah, 13 September 2019.
- “Observation of the Origin of Downward Terrestrial Gamma-ray Flashes in Fast Negative Initial Breakdown Pulses”, invited talk, International Union of Geodesy and Geophysics General Assembly, Montreal, Quebec, Canada 9 July 2019.
- “Ground-Level Detection of Gamma Ray Flashes from Fast Negative IBPs”, American Geophysical Union Fall Meeting, Washington D.C., 12 December 2018.
- “Gamma Rays and the Origins of Lightning”, University of Utah Physics and Astronomy Colloquium, Salt Lake City, Utah, 21 September 2018.
- “Gamma Rays and the Origins of Lightning”, University of Utah College of Science *Science at Breakfast* series, Salt Lake City, Utah, 20 September 2018.
- “Ground-Based Observations of Terrestrial Gamma Flashes Associated with Downward-Directed Lightning Leaders”, invited talk, International Conference on Atmospheric Electricity (ICAE2018), Nara, Japan, 22 June 2018.
- “Downward Terrestrial Gamma Flashes Observed at the Telescope Array Surface Detector”, invited talk, PACIFIC 2018, Akaigawa, Hokkaido, Japan 16 February 2018.
- “Ground-Based Observations of Terrestrial Gamma Ray Flashes Associated with Downward-Directed Lightning Leaders”, invited talk, American Geophysical Union Fall Meeting, New Orleans, Louisiana 13 December 2017.
- “A Particle Astrophysics Observatory and the Origins of Lightning”, Idaho State University Physics Colloquium, Pocatello, ID, 18 September 2017.
- “High-Energy Particle Showers in Coincidence with Downward Lightning Leaders at the Telescope Array Cosmic Ray Observatory”, invited talk, 35th International Cosmic Ray Conference, Busan, Korea, July 2017.

- “High-Energy Particle Showers Observed at Ground Level in Coincidence with Downward Lightning Leaders at the Telescope Array Observatory”, invited talk, UHECR 2016, Kyoto, Japan, October 2016.
- “Recent Observations with the Telescope Array”, invited talk, TeVPA2016, Geneva, Switzerland, September 2016.
- “Cosmic Rays (and other Particles from the Sky) at the Telescope Array Observatory”, University of Utah Physics and Astronomy Colloquium, Salt Lake City 1 September 2016.
- “Study of High-Energy Particles Correlated with Lightning at Utah’s Telescope Array Cosmic Ray Observatory”, invited talk (with R. Abbasi), TGF2016, Huntsville Alabama, July 2016.
- “The Telescope Array RADAR (TARA) Project and the Search for the Radar Signature of Cosmic Ray Induced Extensive Air Showers”, contributed talk, APS April Meeting, Salt Lake City Utah, April 2016.
- “Study of High-Energy Particles Correlated with Lightning at Utah’s Telescope Array Cosmic Ray Observatory”, contributed talk, APS April Meeting, Salt Lake City Utah, April 2016.
- “Recent Results from the Telescope Array Experiment - II”, invited talk, Very High Energy Particle Astronomy (VHEPA) 2016, Honolulu, Hawaii USA, January 2016.
- “The Telescope Array Astroparticle Physics Observatory”, University of Utah Physics and Astronomy Colloquium, Salt Lake City 3 September 2015.
- “Summary of UHECR Composition Measurements by the Telescope Array Experiment”, invited talk, 34th International Cosmic Ray Conference, The Hague, Netherlands, August 2015.
- “Novel Usage for a Cosmic Ray Detector: Study of Lightning at Telescope Array”, invited talk, UHECR2014, Springdale, Utah, October 2014.
- “Composition Working Group Report”, invited talk, UHECR2014, Springdale, Utah, October 2014.
- “Studies of the Highest Energy Cosmic Rays with the Telescope Array Observatory”, invited talk, PACIFIC2014, Moorea, French Polynesia, September 2014.
- “Radar Observation of UHECR with TARA”, invited talk, 14th ICATPP Conference on Astroparticle, Particle, Space Physics and Detectors for Physics Applications, Como, Italy, September 2013.
- “Measuring the Composition of Ultrahigh Energy Cosmic Rays with the Telescope Array Experiment”, invited talk, 14th ICATPP Conference on Astroparticle, Particle, Space Physics and Detectors for Physics Applications, Como, Italy, September 2013.

- “Current and Future Directions in Utah-Based Ultra-High Energy Cosmic Ray Research”, University of Utah Physics and Astronomy Colloquium, Salt Lake City 20 September 2013.
- “Telescope Array: Status and Upgrades”, invited talk, 2013 Community Summer Study, Snowmass on the Mississippi, Minneapolis, July 2013.
- “Bistatic Radar Detection of UHECR with TARA”, invited talk, 33rd International Cosmic Ray Conference, Rio de Janeiro, Brazil, July, 2013.
- “TARA: Radar Detection of UHECRs”, invited talk, Ice Cube Particle Astrophysics Symposium, Madison, Wisconsin, May 2013.
- “TARA: Radar Detection of UHECRs”, invited talk, Cosmic Frontier Workshop, Stanford, California, March 2013.
- “Two Through Your Head Every Second: Cosmic Rays!”, Clark Planetarium “Night School” lecture series, Salt Lake City, UT USA, 21 June 2012.
- “Composition Studies at HiRes and Telescope Array”, invited talk, II Astroparticle Physics Workshop, São Carlos, Brazil, March 2012.
- “TARA: Forward-Scattered Radar Detection of UHECR at Telescope Array”, invited talk, UHECR2012, CERN, Geneva, Switzerland, February 2012.
- “Radar Detection of UHECR Air Showers at the Telescope Array”, invited talk, 32nd International Cosmic Ray Conference, Beijing, China, August, 2011.
- “Forward Scattering Radar for Ultra High Energy Cosmic Rays” (poster), 32nd International Cosmic Ray Conference, Beijing, China, August, 2011.
- “Air Shower Detection by Bistatic Radar”, invited talk, International Symposium on the Recent Progress of Ultra-high Energy Cosmic Ray Observation, Nagoya, Japan, 10-12 December 2010
- “Measurement of UHECR Composition by HiRes”, invited talk, International Symposium on the Recent Progress of Ultra-high Energy Cosmic Ray Observation, Nagoya, Japan, 10-12 December 2010
- “What Rains on the Desert: Particle Astrophysics Under Utah Skies”, *Science Night Live*, Salt Lake City, Utah, 10 November 2010.
- “The Composition of the Highest Energy Cosmic Rays”, invited talk, Quarks 2010, Kolomna, Russia, 12 June 2010.
- “The Composition of the Highest Energy Cosmic Rays”, invited talk, SnowPAC, Snowbird, Utah, 24 March 2010.
- “Composition Studies of the Highest Energy Cosmic Rays with the High Resolution Fly’s Eye Observatory”, invited talk, APS April Meeting, Washington D.C., 16 February 2010.

- “The Composition of the Highest Energy Cosmic Rays”, University of Utah Physics and Astronomy Colloquium, Salt Lake City 21 January 2010.
- “HiRes Composition Studies”, invited talk, Bartol Mini-Workshop on UHECR, University of Delaware, 09 December 2009.
- “Reflections on Carl Sagan”, Carl Sagan Day lecture to student group for Secular Humanism, Inquiry and Free Thought, University of Utah, 07 November 2009.
- “Past, Present, and Future of Ultra-High Energy Cosmic Ray Research in Utah”, Physics Department Colloquium, Utah State University, 27 October 2009.
- “Composition Studies using Depth of Shower Maximum with the High Resolution Fly’s Eye (HiRes)”, APS 4-Corners Meeting, Golden, Colorado, 23 October 2009.
- “Composition Studies using Depth of Shower Maximum with the High Resolution Fly’s Eye (HiRes)”, invited talk, 31st International Cosmic Ray Conference, Lodz, Poland, 13 July 2009.
- “Composition Studies using Depth of Shower Maximum with the High Resolution Fly’s Eye (HiRes)”, invited talk, XXI Rencontres de Blois, Blois, France, 25 June 2009.
- “Status of the TA Fluorescence Detectors”, XXI Rencontres de Blois, Blois, France, 25 June 2009.
- “Composition Studies of Ultra-High Energy Cosmic Rays using X_{max} with the High Resolution Fly’s Eye”, American Physical Conference Spring Meeting, Denver, Colorado USA, 4 May 2009.
- “Two Through Your Head Every Second: Cosmic Rays!”, Lecture to Salt Lake Astronomical Society, Salt Lake City, UT USA, 21 April 2009. (Public Lecture, also given in Bozeman, Helena, Butte and Missoula, Montana.)
- “Cosmic Ray Research in Utah”, AAPT regional meeting, Provo, Utah 7 March 2009.
- “Recent Results from the High Resolution Fly’s Eye”, invited talk, 44th Recontres de Moriond, La Thuile, Italy, 3 February 2009.
- “Recent Results from HiRes”, invited talk, CRIS (Cosmic Ray International Seminar) 2008, Malfa, Salina Island, Italy, 15 September 2008.
- “The FLASH Experiment”, invited talk, CRIS (Cosmic Ray International Seminar) 2008, Malfa, Salina Island, Italy, 15 September 2008.
- “Search for Correlations of AGN with HiRes Stereo Data”, International Astroparticle Physics Symposium, Golden, Colorado 6 May 2008.
- “The FLASH Thick Target Experiment”, invited talk, Fifth Fluorescence Workshop, El Escorial-Madrid, Spain, 20 September 2007.

- “The End of the Cosmic Ray Energy Spectrum”, Physics Department Colloquium, University of Utah, 13 September 2007.
- “Composition Measurements Near the Second Knee with the Telescope Array Low-Energy Extension (TALE)”, invited talk, 30th International Cosmic Ray Conference, Merida, Yucatan, Mexico, July 2007.
- “The Telescope Array Low-Energy Extension (TALE) Infill Ground Array” (poster), 30th International Cosmic Ray Conference, Merida, Yucatan, Mexico, July 2007.
- Rapporteur talk: “Breakout Session #1”, Aspen Workshop on Cosmic Ray Physics, Aspen, Colorado April 2007.
- “TALE Composition Measurements”, Aspen Workshop on Cosmic Ray Physics, Aspen, Colorado April 2007.
- “The FLASH Thick-Target Experiment, Direct Measurement of Air Fluorescence Yield in Electromagnetic Showers”, Aspen Workshop on Cosmic Ray Physics, Aspen, Colorado April 2007.
- “Anisotropy Searches with the High-Resolution Fly’s Eye”, CRIS (Cosmic Ray International Seminar) 2006, Catania, Italy, 30 May 2006.
- “The Telescope Array Experiment and its Low Energy Extension (TA/TALE)”, Tenth Pisa Meeting on Advanced Detectors, La Biodola, Isola d’Elba Italy 26 May 2006.
- “Light at the End of the Tunnel: Overview and Results of the FLASH (FLuorescence in Air SHowers) Experiment”, Physics Department Colloquium, University of Utah, 13 April 2006.
- “Spectrum of UHECR Measured by HiRes”, IX International Conference on Topics in Astroparticle and Underground Physics (TAUP 2005), Zaragosa, Spain, 13 September 2005.
- “Status of HiRes and Energy Spectrum”, “Search for Cross-Correlations of BL Lacs with HiRes Stereo Data”, and “Status of TA/TALE: Telescope Array/TA Low Energy Extension”, Aspen Mini-Workshop on UHECR, Aspen Colorado, August 2005.
- “Arrival Directions of Ultra-High Energy Cosmic Rays within the HiRes-I Monocular Dataset: A Search for Overlaps with the Reported AGASA Clusters” (poster), 29th International Cosmic Ray Conference, Pune, India, August 2005.
- “Search for Pointlike Sources of Cosmic Rays with Energies above $10^{18.5}$ eV in the HiRes-I Monocular Dataset” (poster), 29th International Cosmic Ray Conference, Pune, India, August 2005.
- “The FLASH Thick-Target Experiment: Direct Measurement of Air Fluorescence Yield in Electromagnetic Showers”, 29th International Cosmic Ray Conference, Pune, India, August 2005.

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- “Anisotropy Studies of Ultra-High Energy Cosmic Rays using Monocular Data Collected by the High-Resolution Fly’s Eye (HiRes)”, 28th International Cosmic Ray Conference, Tsukuba, Japan, 31 Jul - 7 Aug 2003.
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