

Editorial

From Vision to Instrument: Creating a Next-Generation Event Horizon Telescope for a New Era of Black Hole Science

Michael D. Johnson ^{1,2,*} , Sheperd S. Doeleman ^{1,2} , José L. Gómez ³  and Avery E. Broderick ^{4,5,6} ¹ Center for Astrophysics | Harvard & Smithsonian, 60 Garden Street, Cambridge, MA 02138, USA² Black Hole Initiative at Harvard University, 20 Garden Street, Cambridge, MA 02138, USA³ Instituto de Astrofísica de Andalucía-CSIC, Glorieta de la Astronomía s/n, 18008 Granada, Spain⁴ Perimeter Institute for Theoretical Physics, 31 Caroline Street North, Waterloo, ON N2L 2Y5, Canada⁵ Department of Physics and Astronomy, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1, Canada⁶ Waterloo Centre for Astrophysics, University of Waterloo, Waterloo, ON N2L 3G1, Canada

* Correspondence: mjohnson@cfa.harvard.edu

In April 2019, the Event Horizon Telescope (EHT) Collaboration successfully imaged a supermassive black hole (SMBH) for the first time, revealing the apparent “shadow” cast by the dark compact object M87* in the center of the elliptical galaxy Virgo A. More recent results include the first polarized images of M87* and the first images of the supermassive black hole in the center of the Milky Way, Sagittarius A*. Together, these results have defined the start of a new era in the detailed study of these exotic objects through images that directly reveal the deflection and capture of light in a strongly curved spacetime.

The next-generation EHT (ngEHT¹) is a program to sharply increase the current EHT capabilities through longer observing campaigns, simultaneous multi-band observations, and the deployment of additional stations at optimal locations worldwide. These enhancements have the potential to again revolutionize our view of horizon-scale physics, enabling movies of black hole accretion and explosive transients, high-dynamic-range images that connect black holes directly to their galactic-scale relativistic jets, and powerful multi-wavelength and multi-messenger synergies with other next-generation facilities. A white paper describing some of these capabilities was submitted to the US Astro2020 Decadal Survey on Astronomy and Astrophysics.²

To develop scientific priorities and their associated requirements, the ngEHT has hosted a series of international meetings that have been entirely open to the scientific community. The first meeting (in February 2021) was virtual and featured 94 presentations, with over 500 participants from more than 30 countries. The second meeting (in November 2021) was also virtual with over 500 registrants, over 100 presentations, and a public outreach panel including prominent YouTube science popularizers. The most recent meeting (in June 2022) was hosted by the Instituto de Astrofísica de Andalucía (IAA) of the Consejo Superior de Investigaciones Científicas (CSIC). The meeting had over 140 participants who convened at the Parque de las Ciencias in Granada, Spain, from 22 to 25 June (see Figure 1). The meeting, titled “Assembling the ngEHT: Community-Driven Science to a Global Instrument”, aspired to unite a large and growing community of black hole researchers and radio interferometry specialists and to find a common purpose that could define the next decade of discoveries.



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Figure 1. The ngEHT meeting at the Parque de las Ciencias in Granada, Spain. This meeting included many leading experts in black hole and EHT science and was jointly coordinated with the EHT Collaboration.

This *Special Issue*³ is an outgrowth of these meetings, with a collection of contributions that develop the scientific vision and architecture of the ngEHT in the following areas:

- Fundamental physics (studies of a black hole spacetime and tests of general relativity).
- Black holes and their cosmic context (SMBH formation and evolution, studies of SMBH binaries, multi-wavelength studies of black holes and jets, and large-scale jet collimation and kinematics).
- Accretion (probing accretion flow dynamics and structure, turbulence, and plasma studies near a SMBH).
- Jet launching (energy extraction from spinning black holes and jet kinematics and monitoring).
- Transients and impulsive phenomena.
- New horizons (terrestrial applications such as geodesy and synergies with other next-generation facilities).
- Algorithms and inference (imaging methods, model fitting to interferometric data, and synthetic data challenges).
- History, philosophy, and culture (implications of building new instruments in the current era).
- Advances in submillimeter VLBI instrumentation and software.
- VLBI array design and optimization.

In addition, this Special Issue contains two summary documents from the ngEHT. The first describes a reference array, instrumentation, and site selection. The second describes the key scientific goals and associated instrument requirements.

Together, the conference and this Special Issue paint an exciting picture of the future of black hole imaging, driven by an extraordinary community of scholars pursuing answers to some of nature's most intriguing secrets through technical breakthroughs and visionary science.

Acknowledgments: We are grateful to the hundreds of scientists and engineers who have contributed to the nGEHT project. In particular, we would like to acknowledge the organizers of the three international science meetings:

February 2021 Meeting (<https://www.ngeht.org/ngeht-meeting-2021> (accessed on 21 August 2023))
Scientific Organizing Committee: Geoff Bower, Avery Broderick (co-chair), Alessandra Buonanno, Vitor Cardoso, Sheperd Doeleman, Charles Gammie, Daryl Haggard, David Hughes, Michael Johnson (co-chair), Chung-Pei Ma, Ramesh Narayan, Ue-Li Pen, Andy Strominger, and Anton Zensus
Local Organizing Committee: Lindy Blackburn, Nick Conroy (co-chair), Mina Himwich, Britt Jeter (co-chair), Tiffany Nichols, Daniel Palumbo, Alex Raymond, and Paul Tiede

November 2021 Meeting (<https://www.ngeht.org/ngeht-meeting-november-2021> (accessed on 21 August 2023))

Scientific Organizing Committee: Lindy Blackburn, Avery Broderick (co-chair), Sheperd Doeleman, Garret Fitzpatrick, Jose L. Gómez, Kari Haworth, Paul Ho, Elizabeth Humphreys, Michael D. Johnson (co-chair), Ilya Mandel, Monika Moscibrodzka, Neil Nagar, Rob Selina, Zhiqiang Shen, Eva Silverstein, Ingrid Stairs, and Meg Urry

Local Organizing Committee: Richard Anantua, Lindy Blackburn (chair), Sandra Bustamante, Razieh Emami, Kotaro Moriyama, Rusen Lu, Elon Price, Venkatesh Ramakrishnan, Angelo Ricarte, Thalia Traianou, and Guang-Yao Zhao

June 2022 Meeting (<https://www.ngeht.org/ngeht-meeting-june-2022> (accessed on 21 August 2023))

Scientific Organizing Committee: Avery Broderick, Ming-Tang Chen, Sheperd Doeleman, Heino Falcke, Garret Fitzpatrick, José L. Gómez (co-chair), Mareki Honma, Michael Johnson (co-chair), Svetlana Jorstad, Yuri Kovalev, Priyamvada Natarajan, and Marta Volonteri

Local Organizing Committee: Antxon Alberdi, Ilje Cho, Rohan Dahale, Marianna Foschi, Antonio Fuentes, Rocco Lico, Ioannis Myserlis, Alicia Pelegrina, Angelo Ricarte, Teresa Toscano, Thalia Traianou (chair), and Guang-Yao Zhao

Conflicts of Interest: The authors declare no conflict of interest.

Notes

¹ <https://www.ngeht.org/> (accessed on 21 August 2023).

² <https://baas.aas.org/pub/2020n7i256/release/1> (accessed on 21 August 2023).

³ https://www.mdpi.com/journal/galaxies/special_issues/ngEHT_blackholes (accessed on 21 August 2023).

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