

Unique imaging of a dinosaur's skull tells evolutionary tale

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Collaboration creates highest-resolution scan of a large tyrannosaur skull

LOS ALAMOS, N.M., Aug. 15, 2017—Researchers using Los Alamos' unique neutron-imaging and high-energy X-ray capabilities have exposed the inner structures of the fossil skull of a 74-million-year-old tyrannosauroid dinosaur nicknamed the Bisti Beast in the highest-resolution scan of tyrannosaur skull ever done. The results add a new piece to the puzzle of how these bone-crushing top predators evolved over millions of years.

“Normally, we look at a variety of thick, dense objects at Los Alamos for defense programs, but the New Mexico Museum of Natural History and Science was interested in imaging a very large fossil to learn about what's inside,” said Ron Nelson, of the Laboratory's Physics Division. Nelson was part of a team that included staff from Los Alamos National Laboratory, the museum, the University of New Mexico and the

University of Edinburgh. "It turns out that high energy neutrons are an interesting and unique way to image something of this size."

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Looking Inside a Tyrannosaur's Skull

The results helped the team determine the skull's sinus and cranial structure. Initial viewing of the computed tomography (CT) slices showed preservation of un-erupted teeth, the brain cavity, internal structure in some bones, sinus cavities, pathways of some nerves and blood vessels, and other anatomical structures. These imaging techniques have revolutionized the study of paleontology over the past decade, allowing paleontologists to gain essential insights into the anatomy, development and preservation of important specimens. Team members will present their findings on the fossil, *Bistahieversor sealeyi*, August 23 at the annual Society of Vertebrate Paleontology meeting in Calgary, Alberta.

To peer inside the 40-inch skull, which was found in 1996 in the Bisti/De-Na-Zin Wilderness Area near Farmington, N.M. the Los Alamos team combined neutron and X-ray CT to extract anatomical information not accessible otherwise and without the risk of damaging the irreplaceable fossil. Los Alamos is one of a few places in the world that can perform both methods on samples ranging from the very small to the very large scale.

The thickness of the skull required higher energy X-rays than those typically available to adequately penetrate the fossil. The Lab's microtron electron accelerator produced sufficiently high-energy X-rays.

To provide an alternate view inside the skull, the team also used a newly developed, high-energy neutron imaging technique with neutrons produced by the proton accelerator at the Los Alamos Neutron Science Center (LANSCE). The neutrons interact with the nuclei rather than the electrons in the skull, as X-rays do, and thus have different elemental sensitivity. This provides complementary information to that obtained with X-rays.

The team's study illuminates the Bisti Beast's place in the evolutionary tree that culminated in *Tyrannosaurus rex*.

"The CT scans help us figure out how the different species within the *T. rex* family related to each other and how they evolved," said Thomas Williamson, Curator of Paleontology at the New Mexico museum. "The *Bistahieversor* represents the most basal tyrannosaur to have the big-headed, bone-crushing adaptations and almost certainly the small forelimbs. It was living alongside species more closely related to *T. rex*, the biggest and most derived tyrannosaur of all, which lived about 66 million years ago. *Bistahieversor* lived almost 10 million years before *T. rex*, but it also was a surviving member of a lineage that retained many of the primitive features from even farther back closer to when tyrannosaurs underwent their transition to bone-crushing."

The Bisti Beast skull is the largest object to date for which full, high-resolution neutron and X-ray CT scans have been performed at the Laboratory and required innovations both to image the entire skull and to handle the image reconstruction from the resulting large data sets.

This work advances the state of the art in imaging capabilities at the Laboratory and is already proving useful in imaging larger programmatic items related to the Laboratory's national security mission.

About the project

This work was funded by Los Alamos National Laboratory capability development funds from the Applied Engineering and Technology division and from National Nuclear Security Administration Science Programs, and through a grant to UNM through the New Mexico Consortium. The team comprised Michelle Espy, Cort Gautier, James Hunter, Adrian Losko, Ron Nelson, and Sven Vogel, of Los Alamos National Laboratory; Tom Williamson, Curator of Paleontology at the New Mexico Museum of Natural History and Science; Kat Schroeder, of the University of New Mexico and Steve Brusatte, of the School of GeoSciences, University of Edinburgh, Scotland.

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