Key words: Deep field image, deep field, early Universe

ESOcast Episode 72: Looking Deeply into the Universe in 3D	
00:00 **[Visuals start]** 1. The MUSE instrument on ESO's Very Large Telescope has given astronomers the best three-dimensional view of the deep Universe ever. By staring for 27 hours into the Hubble Deep Field South region, these new observations reveal the distances, motions and other properties of more galaxies than ever before in this tiny piece of sky. They even go beyond Hubble and reveal previously invisible objects.	**00:00** **[Visuals start]** VLT then MUSE MUSE image sequence
00:42 **ESOcast intro** 2. This is the ESOcast! Cutting-edge science and life behind the scenes of ESO, the European Southern Observatory.	**00:00** ESOcast introduction
01:03 **[Narrator]** 3. Long exposures of the sky have created many deep field images, revealing much about the early Universe. The most famous of these, taken in 1995, was the Hubble Deep Field, which rapidly transformed our understanding of the early Universe. It was followed two years later by a similar view of the southern sky — the Hubble Deep Field South.	 Chandra Deep Field Hubble Deep Field HDF-S

01:32 **[Narrator]** 4. But these images did not hold all the answers. To learn more, astronomers had to then look at each galaxy with other instruments — to split up the light into its component colours and measure distances and other properties. This was a slow and arduous task.	HDF-S Light spectrum
01:55 **[Narrator]** 5. But now the new MUSE instrument can do the same job for all the objects in the field in one go • — and far more quickly.	MUSE footage
02:04 **[Narrator]** 6. One of MUSE's first jobs was a long hard look at the Hubble Deep Field South — and the results exceeded all expectations. Even with a much shorter exposure time than Hubble, MUSE revealed more than twenty very faint objects that Hubble did not see at all.	VLT timelapse Close up of very faint objects in MUSE data.
02:28 **[Narrator]** 7. The MUSE data contain a spectrum for every pixel in the image — about 90 000 in total — telling astronomers about the distance, composition and internal motions of hundreds of distant galaxies. Instead of producing a single image, MUSE produces a stack of thousands of images, each showing the view in a different colour.	Animation on MUSE results
02:57 **[Narrator]** 8. The new observations allowed scientists to measure the distances to 189 galaxies in this area of sky. These are marked with coloured symbols on this image. The colours show how far away the galaxies are - blue and green ones are relatively close	Animation on MUSE results

and pink and purple ones are very distant. They are seen when the Universe was still very young. Triangles are objects that are so faint that they couldn't be seen in the Hubble images at all — but are detected by MUSE.	
03:36 **[Narrator]** 9**.** For closer galaxies, MUSE can even look at how they are rotating, and the way in which their properties vary from place to place. When passing through the MUSE 3d data one side of a rotating galaxy appears before the other as one side is approaching and one receding. The Doppler effect shifts the light either towards the blue or red end of the spectrum.	Animation on MUSE results
04:08 **[Narrator]** 10. The power of MUSE to probe the distant Universe has been demonstrated. Astronomers will now be able to study thousands of galaxies and discover new extremely faint and distant galaxies. These infants — seen as they were more than 10 billion years in the past — gradually grew to become galaxies like the Milky Way that we see today. Studying them at such a young age provides an invaluable window on galactic evolution.	VLT timelapse Distant galaxies
04:42 **[Outro]**	ESOcast is produced by ESO, the European Southern Observatory. *ESO builds and operates a suite of the world's most advanced ground-based astronomical telescopes.*