Nuclear Spin Doctors Uncover Missing Link

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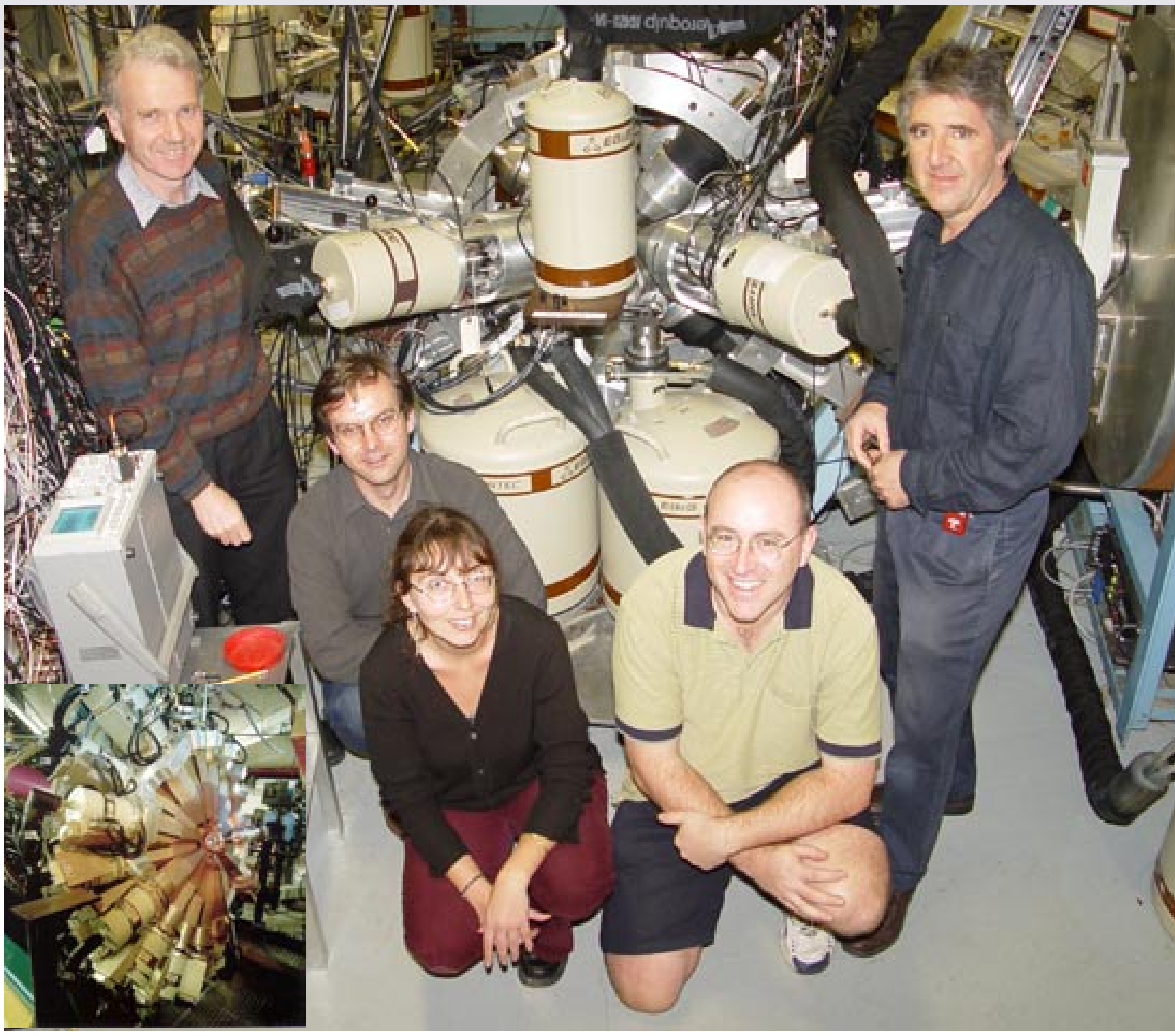
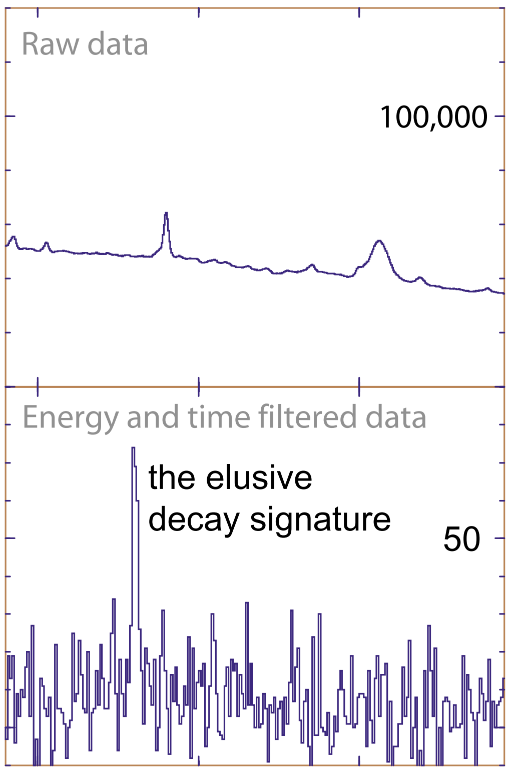
In the mid 1980's scientists made the surprising discovery that some atomic nuclei can spin themselves into highly deformed states without breaking apart. Even more surprising was the discovery that these superdeformed states have lower energies than many of the less deformed intermediate states. This creates a puzzle for scientists. How does the nucleus get from being superdeformed back to spherical without having to overcome the high energy barrier that the intermediate states pose?

The key to understanding this phenomenon lies in studying the gamma rays emitted by the nucleus as it changes shape. It's possible make the nucleus adopt the superdeformed shape using a fusion reaction - but unfortunately, that also creates hundreds of different excited nuclear states only a tiny proportion of which are the superdeformed states of interest. Consequently, the gamma ray signature of the superdeformed nucleus is buried under thousands of other signals. To make matters worse, there can be thousands of possible decay paths from the superdeformed to normal nuclear shapes. This means that even if the superdeformed signature can be isolated, it's still very hard to uncover the signature of the shape change itself. However, scientists at the ANU have recently developed an ingenious solution to this problem. By adapting existing time sensitive data acquisition techniques, they have been able to filter the gamma ray emissions in order to focus their attention on decay pathways leading to particularly long-lived states. In this way the thousands of short lived decay processes that normally swamp the signal can be ignored. It's like trying to hear a pin drop at the same time as a gun shot. If you can delay the pin slightly, and only turn the microphone on after the shot your chances improve dramatically.

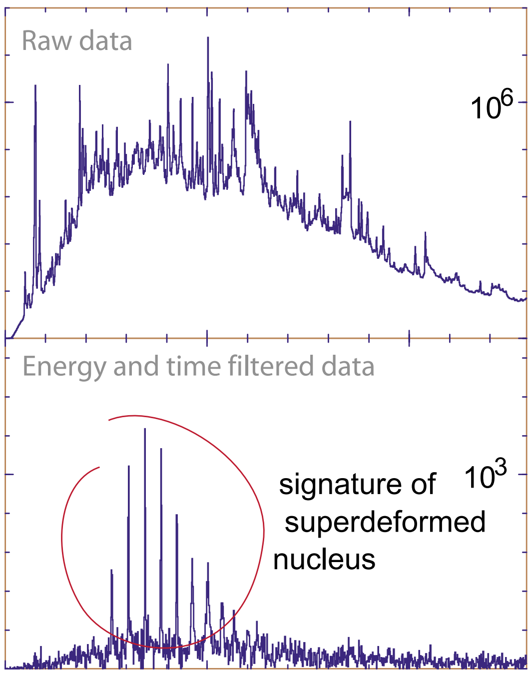
Using these special techniques and the Gamma Sphere facility at Lawrence Berkley National Laboratory in the USA, ANU scientists have been able to identify the illusive superdeformation spectrum for the lead isotope ^{192}Pb. These results look set to inspire a new theoretical investigation of superdeformation decay.



Researchers with the ANU gamma detector and insert: the gammasphere in the USA used to collect this data

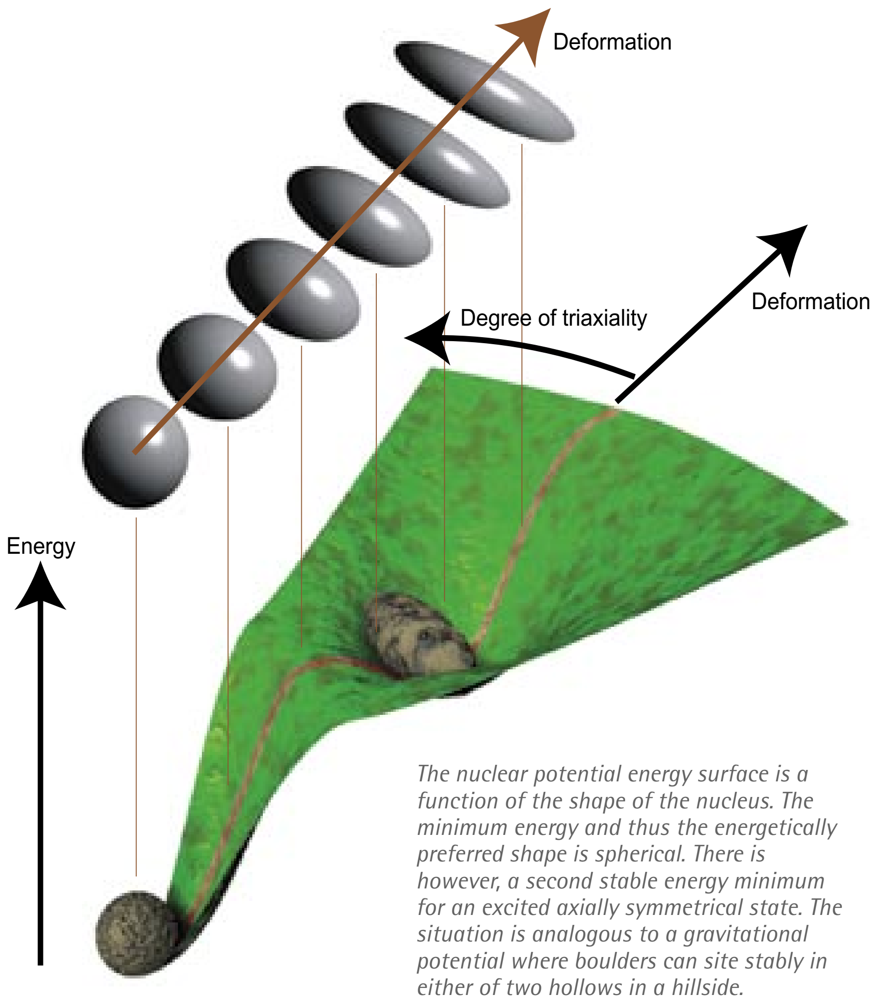


spectra of high energy gamma rays



spectra of low energy gamma rays

Gamma ray spectra before and after application of the new energy and time filters. Prior to filtering, the superdeformation decay was swamped by other emissions 2000 times more intense.



The nuclear potential energy surface is a function of the shape of the nucleus. The minimum energy and thus the energetically preferred shape is spherical. There is however, a second stable energy minimum for an excited axially symmetrical state. The situation is analogous to a gravitational potential where boulders can site stably in either of two hollows in a hillside.

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