I HAD PEANUTS AT THE LITTLE BAR!

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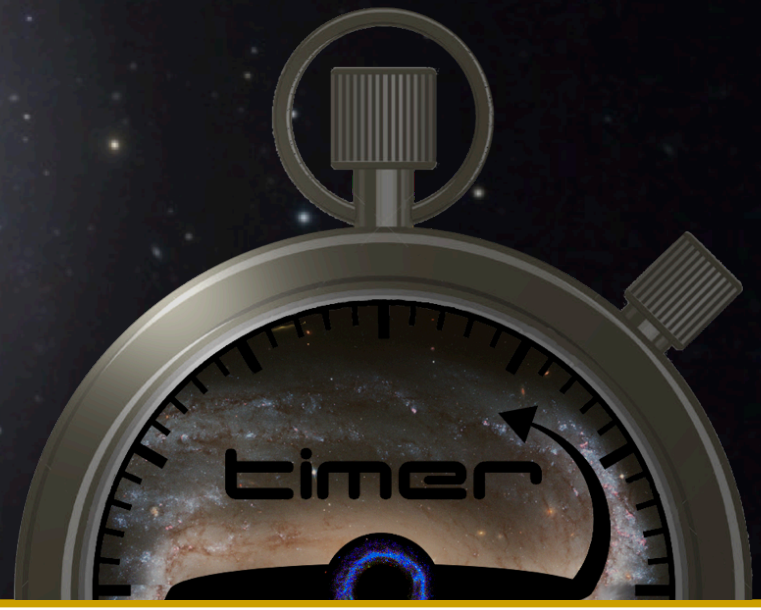
Presenting the first detection of a peanut structure in the inner bar of a double-barred system! *Peanuts are formed after the buckling of stellar bars. Having peanuts in inner bars suggests they are long-lived structures, analogous to regular bars… thus solving the long debate about the nature of double bars.*



THE UNIVERSE IS FULL WITH PEANUTS!

Galaxy peanuts are boxy/X-shaped structures present in many barred galaxies and "easily" detected when the galaxy is viewed edge-on. They actually resemble peanuts!

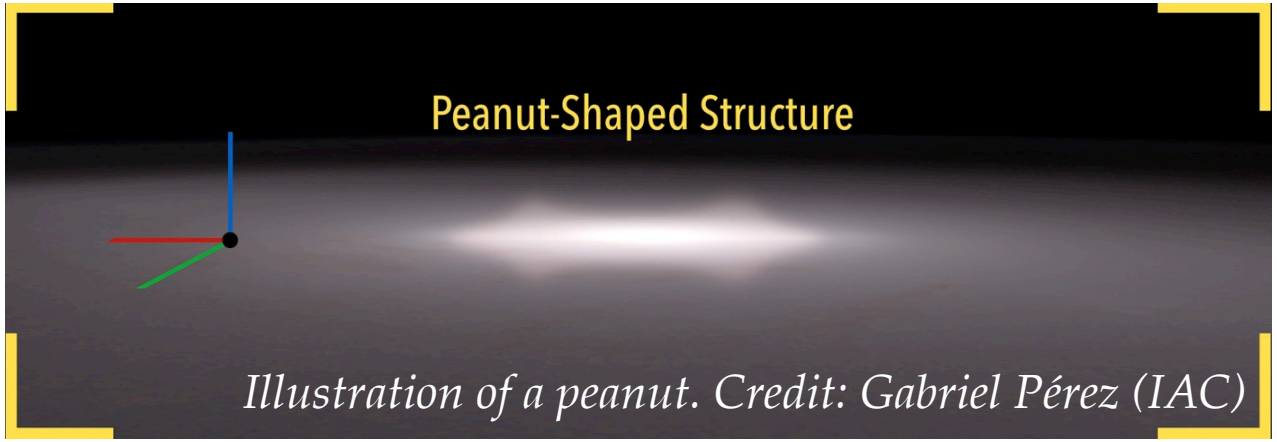
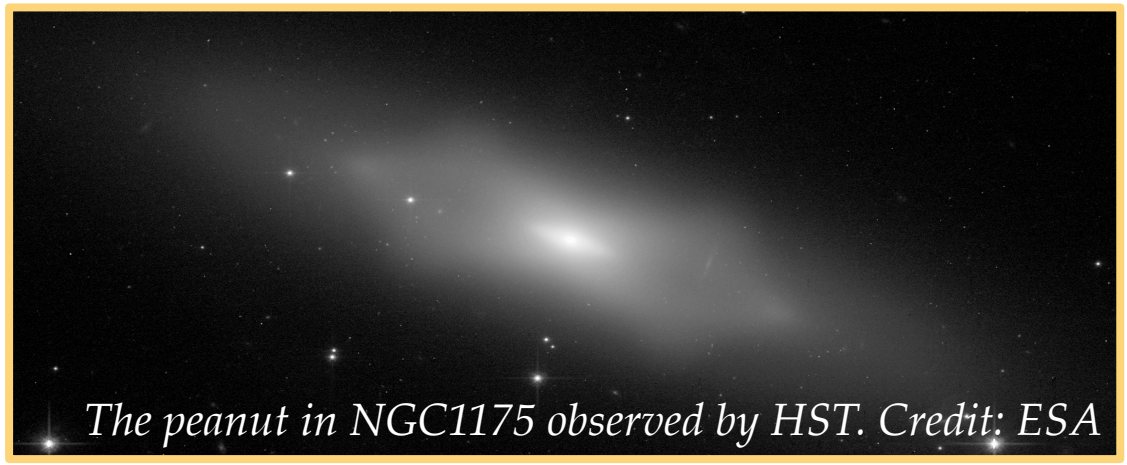
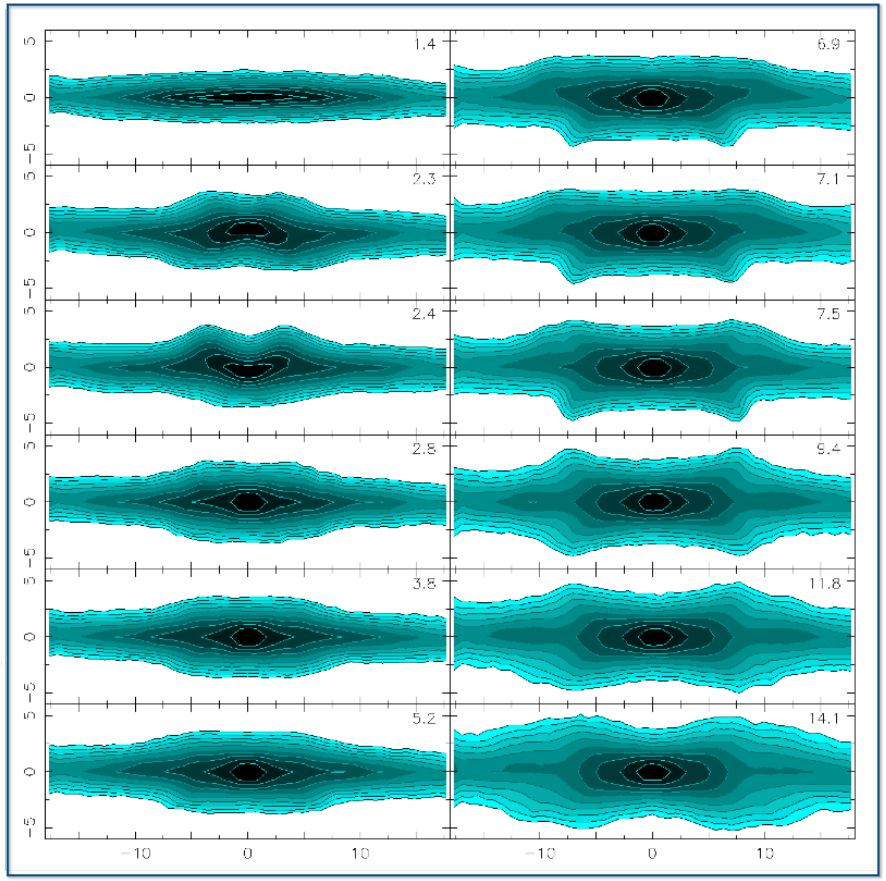


Illustration of a peanut. Credit: Gabriel Pérez (IAC)



The peanut in NGC1175 observed by HST. Credit: ESA

Peanuts are the result of an evolutionary stage of stellar bars called *the buckling phase*, in which the central parts of the bar puff up. Bars buckle >1 Gyr after their assembly. Therefore, **peanuts constrain the formation time and long-living nature of bars.**



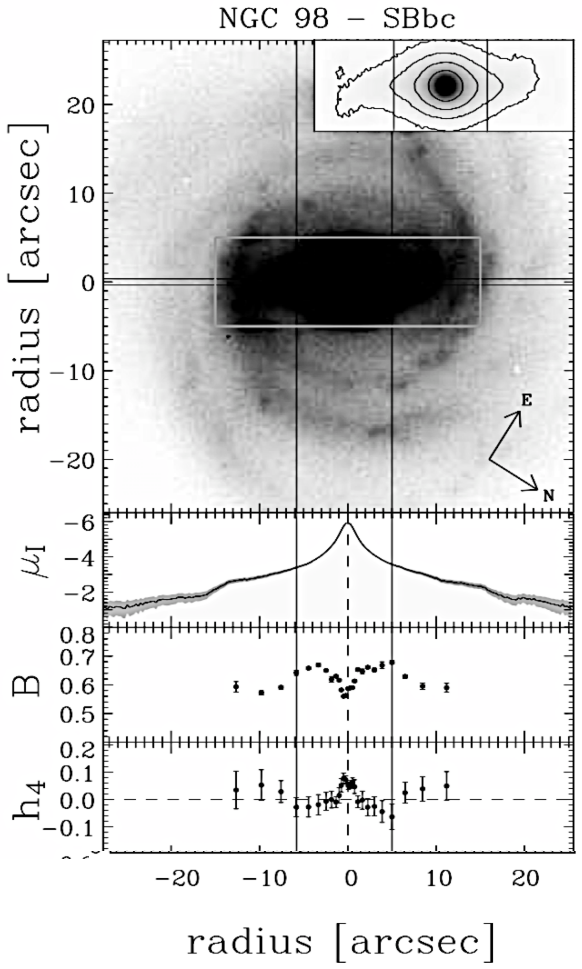
Simulation of the evolution of a stellar bar, including the buckling and peanut formation. Credit: Martínez-Valpuesta et al. (2006)

TWO FACTS ABOUT PEANUTS

1. Detecting peanuts in moderately inclined or face-on galaxies, where the X-shaped structure cannot be seen, is not straightforward!

In 2005, Debattista et al. published a stellar kinematic diagnostics to detect peanuts in galaxies with inclinations $i<30^{o}$: they cause a local minimum of the h_4 moment of the light-of-sight velocity distribution.

Detection of a peanut in the face-on barred galaxy NGC98 through the h_4 minima, indicated with vertical lines. Credit: Méndez-Abreu et al. (2008)



2. Until 2019, all galaxy peanuts had been detected in regular bars, either single bars or outer bars in double-barred systems.

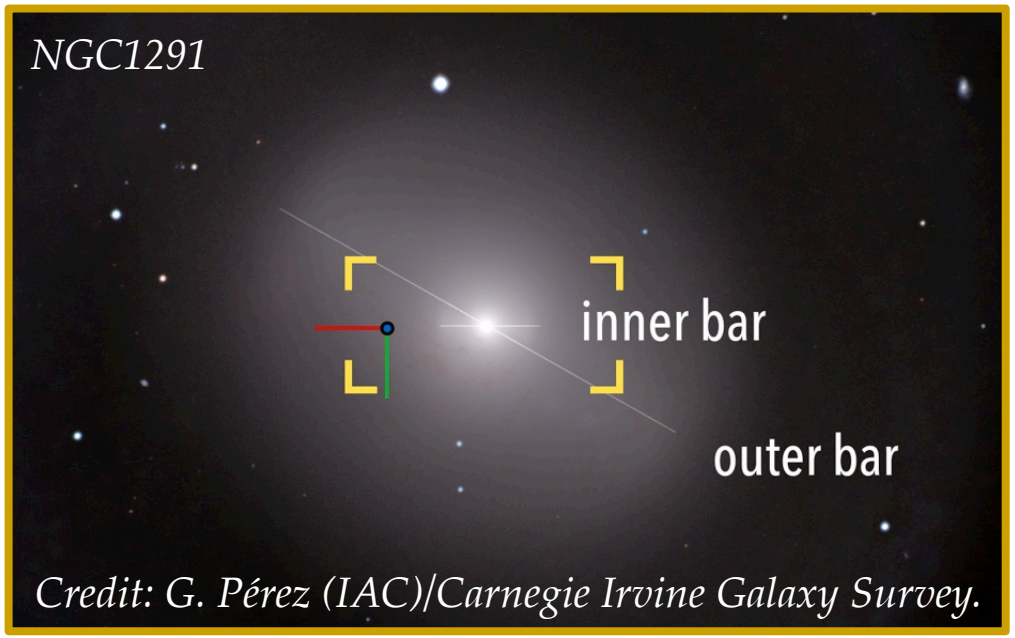
At least 14% of all local barred galaxies are double barred (Hildebrandt et al. submitted). Whether these systems are long lived and how they form remained open questions.

NGC1291 is the first galaxy ever identified as double barred by de Vaucouleurs in 1975. It is a nearby galaxy (8.6 Mpc distant) almost face-on ($i=11^{o}$). Credit: Pöpsel and Binnewies (Cappella Observatory)

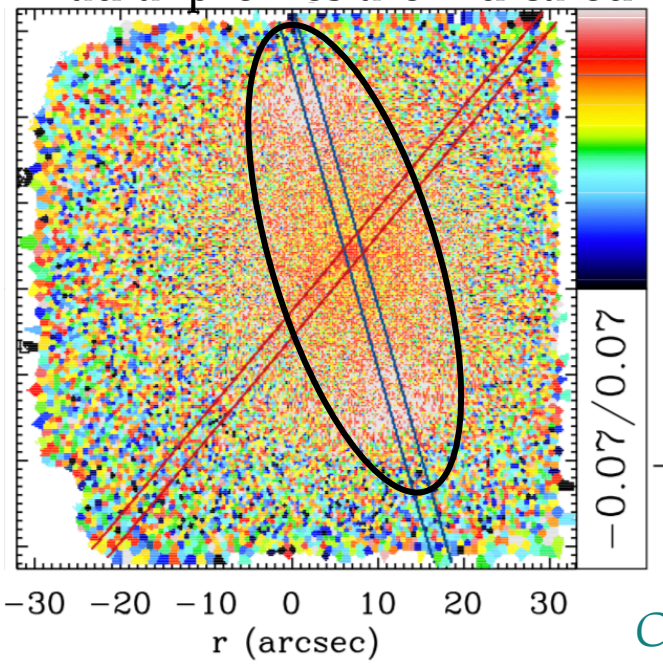
MUSE-TIMER ANALYSIS OF NGC1291

TIMER (Time Inference with MUSE in Extragalactic Rings; PI: D. Gadotti, ESO) is an international effort of >20 researchers from >10 institutions surveying 24 nearby barred galaxies with inner/nuclear structures (rings, discs, bars) with **MUSE@VLT**.

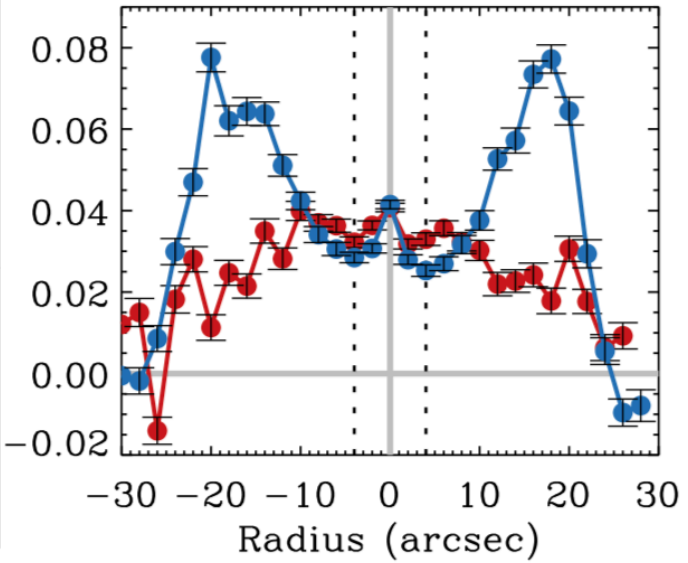
Within **TIMER**, we carefully studied the stellar kinematics and star formation history of the double-barred face-on galaxy **NGC1291**. The local h_4 minima revealing a peanut in the inner bar are particularly clear in the radial profiles (dotted lines).



Stellar h_4 spatial distribution. The ellipse outlines the inner bar. The pseudoslits for the radial profiles are indicated.



Radial profiles of stellar h_4:
- Along the inner bar
- Along the galaxy major axis



Credit: Méndez-Abreu et al. (2019)

CONSEQUENCES OF HAVING PEANUTS AT LITTLE BARS

- **Inner bars are long-lived structures**. Whether inner bars remain or form-and-dissolve even several times after their assembly has been a hot debate for long time (e.g. Wozniak 2015 vs. Englmaier & Shlosman 2004). If inner bars buckle and develop peanuts, they either live for at least 1Gyr… or the timescales involving buckling in inner bars are completely different to those governing regular-sized bars (simulations needed!).

- **Inner bars are small-sized versions of regular bars**. The fact that inner bars buckle and develop peanuts as regular bars suggests they have the same nature and behave analogously. This conclusion has been further confirmed by our TIMER stellar population analysis (de Lorenzo-Cáceres et al. 2019).

To learn more…

Méndez-Abreu et al. 2019, MNRAS Letters, 482, 118

de Lorenzo-Cáceres et al. 2019, MNRAS, 484, 5296

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